

**TRANSACTIONS OF
THE MISSOURI ACADEMY
OF SCIENCE**



Vol. 22, 1988

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Information For Authors

Manuscripts

1. *Editorial Policy.* Authors must pay \$25 per printed page for publication costs. Transactions publishes several types of original contributions from the disciplines within the Academy: research papers, research notes, reviews, and annotated bibliographies. Manuscripts must be authored or co-authored by a member of the Academy. Each manuscript is subject to peer review. The Editor has final authority for acceptance or rejection. Manuscripts should be submitted to the Editor:

Dean Harry J. Sauer, Jr.
Graduate Office
University of Missouri-Rolla
Rolla, Missouri 65401

2. *Manuscript Preparation.* Type all material double spaced, on one side of standard sized bond paper. Submit 4 copies of the manuscript with illustrations for review purposes. Retain the original typescript and illustrations in your files. If accepted for publication, the final copy of the text and original art work will be requested.

Each paper must include an informative abstract which records succinctly the essential findings, followed by a short list of key words for abstracting purposes.

Each table must be typed on a separate page and be suitable for direct reproduction. Number tables consecutively and provide a short title at the top of each page.

All illustrations must be high contrast black and white and reproducible. Handwritten or typewritten lettering or symbols are normally not acceptable.

The manuscript is to be assembled in the following order: title, authors names and affiliations, abstract, key words, text, acknowledgments, literature cited, tables, figure legends, figures. Number all pages.

Authors should refer to current Transactions and a style manual appropriate to the discipline for details on style, format, and citation of references. Use the common and binomial Latin name of an organism when first mentioned. Subsequently the genus or common name may be used. Names of taxa should be underlined.

Abstracts for Annual Meeting:

1. *Editorial Policy.* Authors must pay \$10 per abstract for publication costs. Abstracts are to be submitted to the appropriate section chairperson by 1 March of the year of the meeting.
2. *Abstract Preparation.* Type the abstract as one single-spaced paragraph within a 6½ × 3 inch space using a fresh ribbon. Type the name of the author(s), *not* underlined, and the affiliated institution, using appropriate capital and lower case letters. If co-authors have different institutional affiliations, follow each author's name with their affiliation. Type the title in all capital letters. Continue the paragraph with the main body of the text. Underline generic and specific names. Acknowledgment of support may be included as the last sentence of the text.



About the Academy

Scientists of the State of Missouri organized in 1934 to form the Missouri Academy of Science. By April 6, 1934, a Constitution and By-Laws were prepared and on August 14, 1934, the organization was incorporated.

The purposes of this Academy were presented in the fourth "article of agreement" as follows:

"This corporation is organized, not for profit but for the purposes of promoting the increase and the diffusion of scientific spirit, and of promoting cooperation between the scientific interests of Missouri. It proposes to accomplish these purposes:

- a. By holding meetings for the presentation of scientific papers embodying the results of original research, teaching experience, or other information of scientific interest.
- b. By fostering public interest in scientific matters, through open meetings, press releases, and in such other ways as seem feasible.
- c. By encouraging local scientific organizations in every possible way.
- d. By promoting acquaintance in harmonious relationships between scientists in Missouri, and among all who are interested in science.
- e. By supplying, so far as finances permit, a medium for the publication of results of original work, particularly those of special interest in this state.
- f. By concerning itself with legislation on scientific matters, and providing opportunity for discussion of such legislation.
- g. By working in any and all other ways which may prove feasible, for the advancement of science in Missouri."

The Academy held its organizational meeting on April 13-14, 1934 with 250 people attending. At the December, 1934, meeting, more than 400 people registered and by May, 1935, there were approximately 750 members of the Academy. Statewide interest at a high level continued until activities made necessary by World War II caused disruption of Academy affairs except for some activity in the College Section.

Post-war revival of Academy activities started at a meeting on April 20, 1963 at Drury College. From the group of twelve persons who initiated the reactivation of the Academy in 1963, the membership has grown steadily to more than 800. Activities of the Academy have expanded to include the awarding of modest grants for projects proposed by high-school and college students, and to sponsor the establishment of a Junior Academy of Science.

Since its re-activation in 1963, the Missouri Academy of Science has regularly held annual meetings at 16 different sites around the state. The refereed publication, the *Transactions of the Missouri Academy of Science*, has been published consistently since 1967. Six Occasional Papers have also been released.

Presently, 49 colleges and universities around the State of Missouri hold an Institutional Membership status. Many industries and other private businesses are supporting the Academy with Corporate Memberships.

Membership into the Academy is a year-round opportunity for everyone and runs from January 1 to December 31. Benefits include four quarterly newsletters and the *Transactions*.

The Missouri Academy of Science is a non-profit organization and is supported solely by membership dues and donations. That is why we appreciate each new member and the current members who renew so faithfully each year. And it is because of their interest that the Academy continues its success as a fine scientific organization.

Transactions of The Missouri Academy of Science

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Reviewers of Transaction Papers (Volume 22)

Much thanks to the following persons who have served without tangible reward as reviewers for the full-length papers in this volume of the Transactions. They make this publication a "refereed" journal.

The Editors

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Missouri Academy of Science

1987-1988

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Computer Science	<i>Rochelle Boehning</i> Southwest Missouri State University
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Environmental Science	<i>Michael T. Aide</i> Southeast Missouri State University
Exercise Physiology	<i>Jerry Mayhew</i> Northeast Missouri State University
Forensic Science	<i>Matt Eichor</i> Northeast Missouri State University
Geography	<i>Milton Rafferty</i> Southwest Missouri State University
Geology/Geophysics	<i>John L. Nold</i> Central Missouri State University
Gerontology	<i>Allen J. Edwards</i> Southwest Missouri State University
Herpetology	<i>Bob Aldridge</i> St. Louis University
Linguistics	<i>Ward Sample</i> Central Missouri State University
Oncology	<i>Ali Khojasteh</i> Ellis Fischel Cancer Center
Physics	<i>Robert J. Whitaker</i> Southwest Missouri State University
Psychology	<i>Joseph Hughey</i> University of Missouri-Kansas City
Science Education	<i>Sister Patricia Thro</i> Maryville College
Science, Tech., and Society	<i>Robert E. Smith</i> Allied Bendix Corporation
Social and Behavioral Science	<i>Catherine A. Riordan</i> University of Missouri-Rolla

Sponsors of the Missouri Academy of Science

INSTITUTIONAL MEMBERS have contributed funds to support the activities of the Academy on the basis of 2¢ per FTE student, with a minimum of \$20.00 for colleges with less than 1,000 students. We wish to express our appreciation to the following institutions which were Institutional Members during 1987-88.

Avila College - Kansas City	Missouri Southern State College - Joplin
Central Methodist College - Fayette	Missouri Western State College - St. Joseph
Central Missouri State Univ - Warrensburg	Moberly Area Junior College - Moberly
Cleveland Chiropractic College - Kansas City	Northeast Missouri State University - Kirksville
Columbia College - Columbia	Northwest Missouri State University - Maryville
Cottey College - Nevada	Park College - Parkville
Crowder College - Neosho	Rockhurst College - Kansas City
Culver-Stockton College - Canton	School of the Ozarks - Point Lookout
Drury College - Springfield	Southeast Missouri State Univ - Cape Girardeau
East Central Junior College - Union	Southwest Baptist Univ - Bolivar
Evangel College - Springfield	Southwest Missouri State Univ - Springfield
Fontbonne College - St. Louis	St. Louis College of Pharmacy - St. Louis
Hannibal-LaGrange College - Hannibal	St. Louis University - St. Louis
Harris-Stowe State College - St. Louis	St. Mary's College of O'Fallon - O'Fallon
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Maple Woods Community College - Kansas City	Webster University - St. Louis
Maryville College - St. Louis	William Jewell College - Liberty
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Additional financial support was received from:

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Support specifically for the JUNIOR DIVISION has been received from:

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Missouri Public Service/National Energy Foundation	Charles Granger
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Peter Hansen
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Edward Ortleb
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Fellows of the Missouri Academy of Science

Fellows of the Missouri Academy of Science are among the most highly regarded members of the Academy for their distinguished scientific reputation and their major contributions to the Academy. Nominations for Fellows of the Missouri Academy of Science are solicited by the Committee on Fellows. Nominations should address each of the criteria specified below and should be submitted to Chairman, Committee on Fellows; Missouri Academy of Science; Box 828; Kirksville, MO 63501, by December each year.

Criteria for Designation of Fellow:

1. The nominee has been, and is an active member of the Academy.
2. The nominee has served in a responsible position that has advanced the goals and stability of the Academy.
3. The nomination should cite a specific contribution to the Academy that has enhanced the Academy in its service to its membership.

The Committee on Fellows will review the credentials of the candidates and screen the candidates to no more than three primary nominees. Fellows will be elected by the Executive Council upon recommendation by the Committee on Fellows. Each individual so honored will be recognized for his/her election at an Annual Meeting and receive a plaque designating him/her a Fellow of the Missouri Academy of Science.

1987 Fellows

Eva Kirkpatrick—*Fox C-6 School District*: Eva enlarged the activities of the Junior Division to a dimension never previously achieved. Under the umbrella of the Missouri Academy of Science, she fully integrated the Junior Division into a self-supporting division with fund raising capabilities that are outstanding. Her efforts have made it possible to now have *one* Academy with three active divisions for the purpose of promoting scientific research and understanding.

C. Jerry Nelson—*University of Missouri-Columbia*: Jerry, a long-time member of the Academy, has served as Biology Section chairman and currently chairs the Publications Committee. He was instrumental in developing guidelines for publishing abstracts, in the *Transactions*, which are now recognized as a significant improvement. He also successfully negotiated a contract with the UMC Library for *Transactions* purchases that help put our operation in the black.

Nathan H. Cook—*Lincoln University*: Nathan, a past president of the Academy, is held in high regard and his characteristics include that of being an excellent organizer and a strong administrator. He applied his leadership abilities to the Academy and as a result *many* valuable ideas have been developed and implemented. His endless energy and dedication act as an inspiration to the entire membership.

1988 Fellows

E. Allen McGinnes—*University of Missouri-Columbia*: Al has been a long-time member of the Academy. He served as secretary for three years and is a past president. His assistant served for many years as our photographer, generating excellent publicity at no cost to the Academy. Al also designed and built most of the furniture for the office, which resulted in considerable savings to the Academy. For the past several years he has served as our historian and already has collected most of the pertinent facts relative to the reactivation and growth of our Academy. He and his students have continually presented good papers in our senior division.

David Yourtee—*University of Missouri-Kansas City*: David has been a long-time member of the Academy. During his early years in Columbia he was a great supporter of the collegiate division where one of his interns presented a paper which won first prize. Since their marriage, both have presented excellent papers in the senior division. David is a past president and during his term he introduced a number of creative and innovative changes for the strengthening and growth of our Academy.

Missouri Academy of Science

CONSTITUTION

Approved April 1988

Article 1.

Sec. 1. **Name.** The name of this organization shall be the Missouri Academy of Science, hereinafter referred to as the Academy.

Sec. 2. **Purposes.** The purpose of this organization shall be to increase scientific knowledge and aid in its diffusion, to encourage and support the scientific spirit, to promote cooperation among the scientific interests of Missouri, and to foster the education of its citizenry concerning the constructive role of science and technology in the improvement of the general welfare of our society.

Sec. 3. **Assets.** No part of the net earnings of the Academy shall inure to the benefit of, or be distributable to, its members, trustees, officers, or other private persons, except that the Academy shall be authorized to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the purposes set forth in Article Three hereof. No substantial part of the activities of the Academy shall be the carrying on of propaganda, or otherwise attempting to influence legislation, and the Academy shall not participate in or intervene in (including the publishing or distribution of statements) any political campaign on the behalf of any candidate for public office. Notwithstanding any other provision of these articles, the Academy shall not carry on any other activities not permitted to be carried on by an association exempt from Federal income tax under the provisions of the current Internal Revenue law and any similar laws in the State of Missouri.

Sec. 4. **Dissolution.** Upon the dissolution of the Academy, the Executive Committee shall, after paying or making provision for the payment of all of the liabilities of the Academy, dispose of all of the assets of the Academy exclusively for the purposes of the Academy in such a manner, or to such organization or organizations organized and operated exclusively for educational, or/and scientific purposes as shall at the time qualify as an exempt organization or organizations under the provisions of the current Internal Revenue law and any similar laws in the State of Missouri, as the Board of Trustees shall determine. Any of such assets not so disposed of shall be disposed of by the Court of Common Pleas of the county in which the principal office of the Academy is then located, exclusively for such purposes or to such organization or organizations, as said Court shall determine, which are organized and operated exclusively for such purposes.

Article 2. Membership

Sec. 1. **Eligibility.** Membership shall be open to any individual or organization interested in the objectives of the Academy and who pays the current dues and meets the special requirements of the appropriate membership category.

Sec. 2. Privileges.

- (a) Individual members in good standing shall have the privilege of voting, holding office, offering papers for presentation at the Annual Meeting, and submitting papers for publication. Dues paying members shall receive all publications of the Academy issued during their membership period.
- (b) Institutions, Businesses, Corporations, and other Organizations holding Academy membership shall have the privilege of exhibiting at the annual meetings subject to the policies of the Council. Such members may not vote or hold office.

Sec. 3. Categories of Membership. The membership of the Academy shall consist of the following categories:

- (a) **Individual:** Those persons that have paid the annual dues within the time limit specified, shall be Individual Members. The classifications are determined by the Council.
- (b) **Corporate:** Those corporations, businesses, and/or organizations that have paid the annual dues within the time limit specified, shall be corporate members. The classifications are determined by the Council.
- (c) **Student:** Those persons who are currently enrolled at least half time in any recognized elementary school, high school, college or university, and who have paid the annual dues within the time limit specified, shall be Student Members. Any application for student membership and any renewal thereof shall be endorsed by a member who knows the applicant to be a student.
- (d) **Life:** Those members who shall pay, in one sum, an amount equal to twenty years annual dues, shall be declared Life Members by the Council; such members shall be exempt from further payment of dues.
- (e) **Emeritus:** Those persons who have been dues paying members for at least 15 years, or who have reached the age of 60 years, who have retired from regular gainful occupation because of age and/or disability, and who have formally petitioned and been approved by the Council to be granted this membership status, shall be Emeritus Members. Emeritus Members are exempt from dues and shall receive only a courtesy subscription to the *Bulletin* of the Academy, provided that an annual request is made in writing to the Business Manager.
- (f) **Honorary:** A person of scientific eminence, whether a member of the Academy or not, may be elected an Honorary Member of the Academy by the Council on the basis of distinguished service to science. The person should be a past or present resident of Missouri. Honorary members shall have all the privileges accorded to other members.
- (g) **Institutional:** A college or university that has paid the annual dues within the time limit specified, shall be an Institutional Member. This membership will permit the undergraduate students of that institution to participate in the activities of the Collegiate Division. Any elementary or secondary school may also become an Institutional Member with the same privileges.
- (h) **Affiliate:** Any local, state-wide, or section of a national organization or other not-for-profit scientific institutions (excluding organizations that are eligible for institutional membership) that have similar purposes to that of the Academy may, upon application, be elected an Affiliated Organization. Such Affiliated Organizations may be members of any division in the Academy and have a brief report of their annual meeting published in the *Bulletin*.

Sec. 4. Nomination and Election of Members. Nominations shall be in writing, and may be made by any member and submitted to the Business Manager. Election shall be by the Executive Committee. A member who has voluntarily resigned may be reinstated by the Executive Committee.

Sec. 5. **Expulsion.** The Council shall have power, by majority vote, to expel from membership anyone who, in its opinion, uses his membership in a way that would damage the cause of science or the reputation of the Academy. No person shall be expelled without first being given a copy of the charges against him/her, and provided a fair opportunity to present his/her side of the case.

Article 3. Officers, Executive Committee and Council

Sec. 1. **Elected Officers** of this organization shall be the President, President Elect, Vice President, Secretary, Treasurer, and Historian. Any member who shall have been in good standing for at least one year shall be eligible to hold office.

Sec. 2. **Selection: Term of Office.** The officers in the preceding section shall be elected in the manner set forth in the Bylaws. They shall assume their duties on July 1. The President, President Elect, and Vice President shall serve for a term of one year or until their successors shall have been elected. The Secretary, Treasurer, and the Historian shall each serve for a term of three years.

Sec. 3. **Duties of the President.** The President shall preside at meetings of the Academy, of the Council, and of the Executive Committee; shall have power to make or withdraw appointments, subject to approval of the Executive Committee; shall be an ex-officio member of all committees; shall issue the calls to Academy meetings, as approved by the Executive Committee; shall have other such powers and duties as are usually assigned to this office or as are specified elsewhere in this Constitution and Bylaws. In the event of temporary absence, incapacitation, or death of the President, the duties shall be performed by the first available person in the following order: President Elect, Immediate Past President, Vice President, Secretary, Treasurer.

Sec. 4. **Duties of the President Elect.** The President Elect shall assume the duties of the President at the request of the President or in the absence or incapacity of the President; shall succeed the President at the termination of the latter's term; chair the Past Presidents Committee; serve as an ex-officio member of all committees; keep informed about affairs of the Academy, and be prepared to perform such services as the Academy requires.

Sec. 5. **Duties of the Vice President.** The Vice President shall succeed the President Elect at the termination of the latter's term; be responsible for developing and coordinating the Senior Division program and submitting it for publication in the *Bulletin* for the annual meeting; serve on the Local Arrangements Committee; be prepared to perform such services as the Academy requires.

Sec. 6. **Duties of the Secretary.** The Secretary shall keep the records of the proceedings of the Academy, of the Council, and of the Executive Committee and shall perform such other duties as are usually performed by a secretary.

Sec. 7. **Duties of the Treasurer.** The Treasurer shall make quarterly and annual reports to the Council pertaining to the financial status of the Academy; chair the Finance Committee; serve as a member of the Auditing Committee; perform such other duties as are assigned him by this Constitution and the Bylaws.

Sec. 8. **Duties of the Historian.** The Historian shall compile a set of all academy publications; record the activities of the annual meetings; note significant accomplishments of members and periodically announce these in the *Bulletin*; keep a chronological record of Academy activities on a 3 year basis in a format acceptable for publication in the *Transactions*. The Historian shall perform such other duties as are usually performed by historians and that are in keeping with preserving the record of the Academy and the accomplishments of its members.

Sec. 9. **Executive Committee.** The President, President Elect, Vice President, Secretary, Treasurer, Immediate Past President, Historian, the State Directors of the Junior and Collegiate Divisions shall constitute the Executive Committee of the Academy. The Executive Committee shall:

- (a) Carry out the expressed wishes of the Academy and shall have general supervision of the affairs of the Academy between Council meetings.
- (b) Authorize all expenditures of funds of the Academy by the Business Manager.
- (c) Act on behalf of the Council in matters requiring urgent action, subject to subsequent Council ratification where appropriate.
- (d) Hire and fix the compensation and duties of Academy employees, subject to budget limitation.
- (e) Draft future plans for Council deliberation. Prior to the first Council meeting, consult with appropriate officers and chairs to develop a detailed program of goals and objectives for the coming year, this program, and rational for it, to be presented to the Council for consideration, possible modification, and necessary action.
- (f) Allocate the custody of the property of the Academy.
- (g) Appoint a replacement for any officer other than the President who is unable to complete his term of office by virtue of resignation, disability, or death, unless otherwise stipulated by this Constitution and Bylaws.
- (h) Elect to membership those duly qualified persons as provided for in this Constitution and Bylaws.

Sec. 10. **Council.** The deliberative assembly of the Academy shall be known as the Council, which shall consist of the members of the Executive Committee, Associate Directors of the Junior and Collegiate Divisions, Councilors-at-Large, the Directors of the Collegiate Division Sections, the Co-Directors of the Junior Division Districts, one representative appointed by the Academy of Science of St. Louis, the Chairpersons of all active standing committees, and Chairpersons of the Senior Division Sections. The Council shall manage the affairs of the Academy and shall be responsible for the general planning, policies, and programs for all Academy activities. The Council shall have the power to remove from or appoint to office the Editors for the *Transactions*, *Bulletin*, and *Occasional Papers*. The Council shall hold at least two (2) meetings annually. The Council may hold additional meetings on reasonable notice, upon call of the President.

Sec. 11. **Councilors-At-Large.** Each President shall, at the beginning of his term of office, have the authority to appoint two members in good standing to serve on the Council for a three year term. These appointees are dedicated but not restricted to providing industrial interaction with the Academy.

Sec. 12. **Section Chairpersons.** Each section of the Senior Division shall elect a Chairperson who shall serve for a term of one to three years, or until his successor is chosen; shall have the power to invite, to accept, or reject papers for the annual meeting; in case any section shall fail to elect a chairperson, the Vice President may appoint a Chairperson or assume responsibility for arranging meetings of the section in question with power to invite and to accept or reject papers for presentation at the sectional meeting. A chair elect may be elected by each section to assist the chair.

Article 4. Business Manager

Sec. 1. **Duties.** The Business Manager shall supervise the central office and all business operations of the Academy, except those delegated to others by the Executive Committee, act as the Academy's registered agent, receive and disburse all monies related to Academy

business according to the policies established by the Executive Committee, furnish bond in such amount and by such company as the Executive Committee shall require with the expense of such bond to be paid by the Academy, and to enhance and extend the effectiveness of the Academy in attaining its goals. The Business Manager shall be an ex-officio, non-voting member of the Executive Committee, the Council, and all standing committees. Specific duties may include, by mutual agreement:

- (a) Prepare the agenda for each meeting of the Executive Committee or Council and send out notices of meetings.
- (b) Assist the Finance Committee in the preparation of the budget of income and expenditures for the next fiscal year for presentation to the Council for approval or amendments.
- (c) Prepare the federal and state income tax returns and maintain financial records.
- (d) In cooperation with the Membership Committee, maintain accurate membership records.
- (e) Coordinate the plans and arrangements for the annual meeting.
- (f) Serve as managing editor of the Academy's *Bulletin*. This responsibility may be delegated to a member with approval of the Council.
- (g) Handle the distribution of publications of the Academy.
- (h) Keep an inventory of Academy property and a record of the location of such property.

Article 5. Meetings

Sec. 1. **Annual meetings.** Annual meetings shall be called each year by the President at such time and place as the Council shall designate.

Sec. 2. **Other Meetings.** Regional and Sectional Meetings shall be arranged by the Executive Committee and by the Section Chairpersons whenever feasible and desirable for the advancement of the purposes of the Academy.

Sec. 3. **Affiliate Societies.** Affiliate societies may meet in conjunction with the annual meeting of the Academy.

Article 6. Divisions of the Academy

The Missouri Academy of Science shall consist of a Junior Division, a Collegiate Division, and a Senior Division, whose organization and operations shall satisfy the following provisions.

Sec. 1. **The Missouri Junior Academy of Science** shall constitute the Junior Division of the Missouri Academy of Science.

Sec. 1a. **The Junior Division** shall be subject to the Constitution and Bylaws of the Academy, but it has the delegated authority to establish those operational bylaws that it may require for its organization and operation. No bylaws may be established which are in conflict with those of the Academy.

Sec. 1b. **Members of the Missouri Junior Division** are eligible for student membership in the Missouri Academy of Science, and are encouraged to initiate and maintain such an affiliation.

Sec. 1c. **The Junior Division** shall hold its annual meeting in conjunction with that of the Missouri Academy of Science.

Sec. 2. **The Collegiate Division of the Missouri Academy of Science** shall constitute the Collegiate Division of the Academy.

Sec. 2a. **The Collegiate Division** shall be subject to the Constitution and Bylaws of the Academy, but it has the delegated authority to establish those operational bylaws that it may require for its organization and operation. No bylaws may be established which are in conflict with those of the Academy.

Sec. 3. **The Senior Division** shall be organized according to Sections devoted to the interests of a special science or group of sciences, or of a teaching group or other similar group with common interests, subject to the approval of the council.

Sec. 3a. **Formation of Sections.** Any ten members may petition to the Council requesting approval of the formation of a section devoted to their interests.

Sec. 3b. **Dissolution of Sections.** Any section that has not met with the Academy at its annual meeting for three successive years, or whose membership has been less than ten for two successive years, shall be considered inactive, and terminated. This shall not prejudice consideration for reinstatement, which will require the procedure described in Section 3a.

Sec. 3c. **Method of Joining.** Any individual dues paying member of the Senior Division may belong to any section by notifying the Business Manager of the Academy, in writing, of his/her desire to be a member of such section.

Article 7. Affiliations

Sec. 1. **Outside Affiliations.** This Academy may become affiliated with other organizations of similar purpose, if such course is approved by the Council. Delegates to such affiliated organizations, when required, shall be appointed by the President.

Article 8. Amendments

Sec. 1. **Amendments to Constitution.** This Constitution may be amended at any time by assent of two-thirds of the votes cast at the annual meeting, provided that a copy of the proposed amendment, approved by a majority of the Council, has been sent to the voting membership at least thirty (30) days before the date of the meeting.

Article 9. Bylaws

Sec. 1. **Enabling Provision.** This Academy shall adopt such bylaws, not inconsistent with this Constitution, as are necessary or desirable to aid in carrying on the business of this organization.

BYLAWS

Article 1. Quorum

Sec. 1. **At Academy Meetings.** Ten members shall constitute a quorum for the transaction of business at any meeting of the Academy.

Sec. 2. **At Council Meetings.** Five members shall constitute a quorum of the Council.

Sec. 3. **Executive Committee.** A majority of the Executive Committee shall constitute a quorum.

Article 2. Finances

Sec. 1. **Fiscal Year.** The fiscal year of the Academy shall begin July 1 and extend through June 30 of the following year.

Sec. 2. **Annual Dues.** The annual dues charged members of the Academy including fees for the annual meeting, shall be determined by the Council.

Sec. 3. **Non-Payment of Dues.** Any member who becomes in arrears for dues for more than six (6) months, shall be considered to have resigned, and his name shall be dropped from the roll of members by the Secretary without further action, except that the member shall be given at least sixty days notice before such action is taken. Members dropped from the roll in this manner shall be required to pay the dues for the year which they are in arrears, and for the current year, before they may be reinstated to membership.

Sec. 4. **Special Assessments.** No special assessments may be levied except by two-thirds vote at an annual meeting of the Academy, following recommendation by the Council. Non-payment of special assessments shall be subject to the same penalties as described for non-payment of dues.

Sec. 5. **Funds of the Academy.** Funds of the Academy shall be designated as *Current Funds* and *Endowment Fund*, and maintained in separate accounts.

- (a) Current funds shall include all dues of members, all receipts from publications, and all other funds received in the continuing operation of the Academy.
- (b) Endowment funds shall include all gifts and bequests received to further the objectives of the Academy whether or not restricted as to the use to be made of the principle and income, and such other funds as may be designated by the Council as Endowment Funds.

Article 3. Meetings

Sec. 1. **Notice of Meetings.** At least thirty (30) days notice of all meetings shall be given by the Business Manager to the members of the Academy.

Sec. 2. **Requirements for Papers.** No papers shall be given a place on the printed program of the annual meeting of the Academy unless the manuscript, or an abstract of it, is received by the deadline date established by the Vice President, except by special action of the Executive Committee. If abstract is to be published in the *Transactions*, an abstract fee must be submitted.

Sec. 3. **Time Limit on Papers.** No paper shall be allotted more than fifteen minutes on any program of the Academy except by special action of the Executive Committee.

Sec. 4. **Temporary Combining of Sections.** The Vice President, in communication with the section chairpersons involved, shall have power to arrange for the joint meeting of two or more sections in any case where the papers to be presented justify such action.

Sec. 5 **Conflicts Forbidden.** Section meetings shall not be permitted to conflict with announced general sessions of the Academy except by special action of the Council.

Article 4. Nomination and Election of Officers

Sec. 1. **Nominations.** The Nominations and elections Committee shall nominate at least one member for each vacant office of the Academy. At the annual meeting, the President shall give opportunity for further nominations from the floor.

Sec. 2. **Elections.** All elections shall be carried out at the annual meeting, and a majority for the votes cast shall be necessary for election. In case more than two candidates are nominated, and none receives a majority vote on the first or second ballot, the name receiving the lowest number of votes shall be dropped from the list on the third ballot; and this procedure shall be repeated on successive ballots until one candidate receives a majority.

Article 5. Transaction of Business

Sec. 1. **Order of Business.** The following order of business is suggested for annual meetings:

1. Call to order.
2. Minutes.
3. Reports of Officers; Announcements.
4. Reports of Committees
5. Unfinished Business
6. New Business
7. Election of Officers
8. Adjournment

The President shall have power to vary from this order, at his/her direction.

Sec. 2. **Parliamentary Authority.** In points not covered in the Constitution and Bylaws, *Robert's Rules of Order* shall be the authority in matters of procedure and order.

Article 6. Committees

Sec. 1. **Standing Committees**, listed in alphabetical order, shall be:

Auditing
 Corporate Membership
 Finance
 Grants, Fellowships, and Scholarships
 Individual Membership
 Institutional Membership
 Nominations and Elections
 Local Arrangements
 Past Presidents Committee
 Publications
 Public Information
 Recognition and Awards
 Science Talent

Unless otherwise specified, appointment of these committees shall be by the President, with the concurrence of the Executive Committee.

Sec. 2. The composition and duties of the Standing Committees of the Council are as follows:

- (a) **Auditing.** This committee shall be composed of three members each serving three years, one being appointed each year, and the Treasurer. The chair shall be

designated by the President. The committee shall examine the records of the Business Manager for the closing fiscal year, and shall report their findings to the Council.

- (b) **Corporate Membership.** This committee shall be composed of at least three members each serving for three years, one being appointed each year. The chair will be designated by the President. The committee shall develop and conduct at least annually, a membership drive to increase membership in this category and minimize attrition.
- (c) **Finance.** This committee shall be composed of at least three members each serving for three years, one being appointed each year, the chairs of the Corporate, Individual and Institutional Membership committees, and the chair of the Local Arrangements committee. The chair shall be the Treasurer. It shall recommend membership dues in all categories, an annual budget, fees for attendees, participants and exhibitors at the annual meetings. The committee shall be advisory to the Council in all financial matters. It shall seek optimum return on Academy investments and income property and recommend specific expenditures.
- (d) **Grants, Fellowships, and Scholarships.** This committee shall be composed of at least three members each serving for three years, one being appointed each year. The Chair shall be designated by the President. This committee shall develop and disseminate the guidelines and procedures for awarding Grants, Fellowships, and Scholarships. Selection of the awardees shall be made by this committee with the approval of the Council. Income from the Endowment Fund and other sources may be used for this purpose.
- (e) **Individual Membership.** This committee shall be composed of at least three members each serving for three years, one being appointed each year. The chair will be designated by the President. The committee shall annually conduct a membership drive to increase membership and devise strategies to minimize attrition in all categories except corporate and institutional.
- (f) **Institutional Membership.** This committee shall be composed of at least three members each serving for three years, one being appointed each year. The chair will be designated by the President. The committee shall develop and conduct at least annually, a membership drive to increase membership in this category and minimize attrition.
- (g) **Nominations and Elections.** This committee shall be composed of at least three members each serving three year terms, one being appointed each year; no more than one member may be a member of the Executive Committee; the chair shall be appointed by the president. The committee shall solicit nominations from the membership and nominate candidates for vacant offices for the annual elections. The committee shall gather biographical data on each candidate to be published in the program *Bulletin* for the annual meeting. It shall consult with the Executive Committee on potential candidates for interim appointments for vacated offices. It shall supervise the preparation of ballots and receive, count and disseminate to the President the results of all elections.
- (h) **Local Arrangements.** This committee shall be composed of the Vice President and all section Chairs. The Chair shall be appointed by the President. The Chair may appoint other members necessary for the proper functioning of the committee. This committee shall:
 - (1) develop general plans for the forthcoming Annual meeting. It shall coordinate the technical program and symposia; prepare announcements, advertising, and the program agenda for publication in the *Bulletin*;
 - (2) solicit exhibitors;
 - (3) recommend possible funding to the Council for invited speakers (Symposia, Senior Division, etc.);

- (4) provide information concerning hotels, motels, and other overnight facilities to be included in the *Bulletin*;
- (5) evaluate the Annual meeting no later than October 1 following the meeting and make recommendations for the next annual meeting;
- (6) recommend to the Council sites for future Annual meetings of the Academy; the Academy should have established at all times the sites for at least the next two years Annual meetings.
- (i) **Past Presidents Committee.** This committee shall consist of at least six past presidents or members each serving three year terms, two being appointed each year; and the President Elect. The chair shall be the President Elect. This committee shall be responsible for the structural and functional aspects of the Academy standing committees. It shall recommend names to the President Elect for staffing yearly and unanticipated vacancies on these committees, giving consideration to: (1) balanced representation; (2) the number of committees and duties which a potential nominee is serving; (3) the principle of rotation of committee assignments; and (4) the responses from the membership to a periodic survey of member interests in and qualifications for service on a committee.
- (j) **Publications.** This committee shall be composed of at least three members each serving three year terms, one being appointed each year; Chair of the Finance committee; and the Editor of the *Transactions*, the Editor of the *Bulletin*, and when applicable, the Editor of the *Occasional Papers* (both ex-officio). The Chair shall be appointed by the President. This committee shall establish subscription prices, page charges, abstract fees, reprint costs and other policies for all publications for recommendation to the Council. It shall establish procedures for submission, review, acceptance and rejection of manuscripts, copyright, and other appropriate aspects of the Academy's publications. It may nominate individuals to fill vacant Editor or Associate Editor positions to the Council. It may negotiate contracts with libraries and other organizations with approval of the Council. It shall recommend to the Council and oversee a publications budget that is primarily to support publication of the *Transactions*
- (k) **Public Information.** This Committee shall consist of at least three members each serving three year terms, one being appointed each year. The Chair shall be designated by the President. This committee shall conduct activities which will foster the public understanding of science through the various media. It shall also seek ways of increasing the visibility of the Academy and the Academy's programs.
- (l) **Recognition and Awards.** This committee shall be composed of at least two Past Presidents and the Immediate Past President. Appointments will be made by the President. The Chair shall be the Immediate Past President. This committee shall implement procedures for recognition by the Academy of individuals or groups outstanding in attaining the objectives of the Academy. The committee shall develop and recommend to the Council the criteria to be used in selecting the awardees. The committee shall submit nominations to the Council for approval for the following awards: *Outstanding Scientist of the Year*, *Fellows*, and *Honorary Members*. It shall publicize the awards and solicit nominations from the membership annually.
- (m) **Science Talent.** This committee shall be composed of at least three members each serving three year terms, one being appointed each year; and the State Director of the Junior Division of the Academy. The President shall designate the Chair. This committee shall evaluate the entries in the Annual Science Talent Search and select the Missouri Science Talent Search honor winners. The committee shall notify the winners and present the awards at the MJAS banquet.

Sec. 3. **Special Committees** may be appointed, as necessary, by the President.

Sec. 4. Standing Committees may be established or declared inactive by approval of the Council.

Article 7. Publications

Sec. 1. There shall be three publications offered by the Academy, called *Bulletin*, *Transactions*, and *Occasional Papers*.

A) The *Bulletin* shall be a medium of communication with the membership, primarily for information of current interest. The material contained is not intended to be archival. It shall be published at least quarterly, and as economically as feasible within the constraints of adequate communication.

B) The *Transactions* shall be an archival publication containing: (1) individual, peer reviewed papers contributed by members, (2) Proceedings of Symposia held under the auspices of the Academy and (3) Proceedings of other symposia and conferences whose organizers may petition the Academy to sponsor their publications as an issue of the *Transactions*.

C) An *Occasional Paper* shall be an archival publication containing a peer reviewed article, or monograph, or Proceedings, whose length or character would make it unsuitable for including in the *Transactions*.

Sec. 2. *Bulletin* shall contain, but not be limited to, Academy, Council and Executive Committee transactions; listings of the names, addresses and phone numbers of all officers and Section Chairpersons; the official program of the annual meeting; communications of importance to the membership and communications of interest to specific sections. The Council shall have full authority and responsibility for the *Bulletin*. Ordinarily, it shall be published quarterly.

Sec. 3. **Duties of the Editor of the *Bulletin***. The Editor shall be responsible for all phases of the publication of the *Bulletin*. Since the *Bulletin* is the principal mechanism for written communication to the membership, the Editor will publish all communications of the Academy, the Executive Committee, and the Council as first priority and include, as space permits other items consonant with the stated objectives of the Academy. The Editor is responsible for reporting annually to the Council.

Sec. 4. *Transactions*. So far as finances permit, the Academy shall publish a *Transactions* to appear at least annually. It shall contain the Constitution and Bylaws if these have been amended since the last annual meeting before publication. It shall publish the abstracts from the annual meeting if the appropriate fee has been paid. It shall publish also approved papers reporting the research of members where approval is obtained through a peer review system and, when deemed appropriate, proceedings of symposia. The Council shall have full authority and responsibility for establishment of editorial policy and shall appoint an editor of the *Transactions* to administer this policy and accomplish publication.

Sec. 5. **Duties of the Editor of the *Transactions***. The Editor shall be responsible for the maintenance of scientific quality, management and publication of the *Transactions of the Missouri Academy of Science*. In general, the Editor will be obligated to implement the stated objectives of the Academy insofar as the publication of a learned, refereed journal contributes to those objectives. The Editor is an ex-officio member of the Publications Committee and will be responsible for reporting to the Council at the annual meeting. This report will also be published in the *Bulletin*.

Sec. 6. *Occasional Papers* shall be published at irregular intervals, as need dictates. The Council shall have full authority and responsibility for establishment of an editorial policy, and shall appoint an Editor of the *Occasional Papers* to administer this policy and to accomplish publication.

Sec. 7. Ultimate authority and responsibility related to Academy publications resides with the Council; however, the Council may delegate specific items of its authority to a Publications Committee. The Publications Committee may, in turn, delegate specific aspects of its authority to the publication editors.

Article 8. Amendments

Sec. 1. **Amendment to Bylaws.** The Bylaws may be amended at any time by assent of two-thirds of the votes cast at the annual meeting, provided that a copy of the proposed amendment, approved by a majority of the Council, has been sent to the voting membership at least thirty (30) days before the date of the meeting.

As adopted the nineteenth day of May, 1934, amended the twenty-eighth day of April, 1972, the twenty-seventh day of April, 1973, the twenty-fifth day of April, 1975, the twenty-ninth day of April, 1977, the twenty-fourth day of April, 1982, and the thirtieth day of April, 1988.

Parallel Distributed Processing

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Introduction

An old idea in Computer Science has been rejuvenated over the past several years to the extent that it is currently one of the more exciting topics in the field. Known as Parallel Distributed Processing, Neural Network Computing, Artificial Neural Networks, Neuromorphic Systems, etc., it is, in essence, an analog computation.

We are all familiar with analog methods of computation that are quite distinct from the electromechanical gadgets of the 1940-50's era. For example, numerical quadrature by weighing a cutout of a piece of graph paper, estimating the volume of an irregular solid by measuring the water it displaces, and recording in the focal plane of a convex lens, the Fourier Transform of a slide illuminated by laser, are all analog computations.

These processes have in common certain attributes. The computation is holistic in that the final result is not built up by a sequence of elemental results but is produced at once in its entirety. That is, the processing occurs in parallel. This is especially evident in the Fourier Transform example, where as a consequence of Huygen's Principle, a given point of the input slide contains information that is distributed over the entire focal plane. Furthermore, each point in the focal plane receives information from all points of the input. These remarks are intended to emphasize the parallel and distributed nature of the process.

One author, Kohonen,¹ finds it useful to describe the process in terms of those computations that neural networks do *not* perform:

1. No digital logic is performed.
2. There are no bistable memory elements.
3. There are no instructions or control codes.
4. The process is non-algorithmic.
5. A Neural Network does not operate in any way like a digital computer.

Kohonen goes on to offer a definition:

Artificial Neural Networks are massively parallel interconnected networks of simple (usually adaptive) elements and their hierarchical organizations, which are intended to interact with objects of the real world in the same way that biological nervous systems do.

A definition by Wasserman and Schwartz² emphasizes the attributes that are peculiar to biological systems:

Neural Networks are highly simplified models of the human nervous systems, exhibiting abilities such as learning, generalization, and abstraction.

Historical Background

The first suggestion that a network could be designed to perform computational tasks in parallel is attributed to McCulloch and Pitts³ in 1943. For several years, this concept received considerable attention. Networks of input and output computational units were shown to be capable of learning certain tasks but when Minsky and Papert⁴ demonstrated the failure of a simple I/O network to solve the Exclusive OR problem, interest declined rapidly. The Minsky-Papert result was cited as evidence that the network approach to computation was likely to be sterile. A few non-believers in the Minsky-Papert viewpoint continued their studies and, since 1980, a flood of articles has appeared in the scientific literature.

The Exclusive OR

A pair of binary digits is to be presented to a pair of input terminals. At the single output terminal, a single binary digit is to appear according to the following rules:

Input	Output
0 0	0
0 1	1
1 0	1
1 1	0

A sketch of this arrangement is displayed in Figure 1.

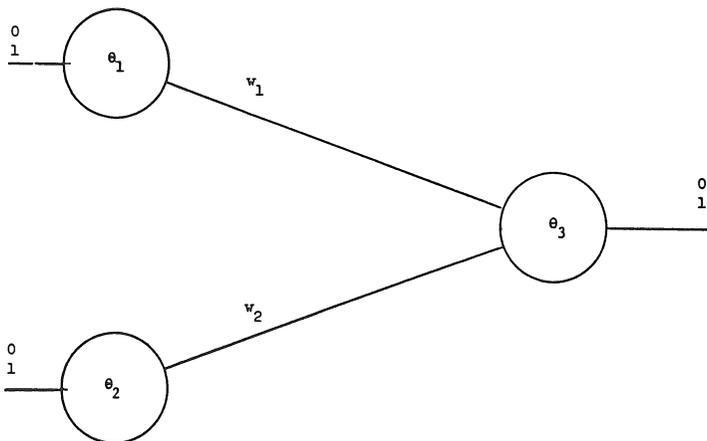


Fig. 1.

Minsky and Papert showed that no matter what switching process is available at each node, this network cannot solve XOR. The refutation of this result comes from a "Hidden" node as shown in Figure 2. The numbers linking the nodes are weights that multiply the signal; numbers inside of the nodes are thresholds. When the total weighted signal entering a node exceeds the threshold, the node transmits a signal; otherwise, it does not. The positive weights contribute to the passage of a signal through the network while a negative weight tends to inhibit its passage. It is clear from Figure 2 that the introduction of a single hidden unit with appropriate thresholds and weight connections is sufficient to solve the XOR problem. A detailed discussion of these ideas may be found in the work by McClelland and Rumelhart.⁵

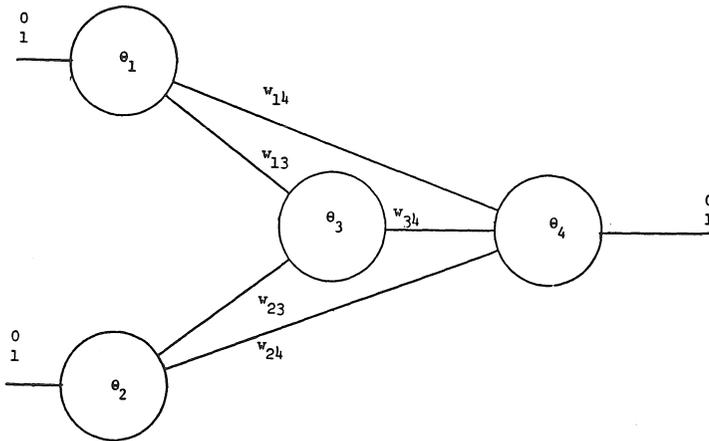


Fig. 2.

The Artificial Neural Network

A network is a collection of input nodes, a multitude of interior "hidden" nodes connected to the input nodes and to each other, and connected finally to output nodes where a signal appears in response to a signal presented as the input. As the input signal passes through the network, it is modified by the internal nodes, connections, and weights. The output is, of course, a function of the interior structure as well as of the input signal. The adjustments of the interior parameters to produce the desired output can be conceptualized as "teaching" the network to perform a task correctly. In the neural analogy, the input nodes are receptors (or perhaps in total, a retina). The interior nodes represent neurons whose duties include summing incoming signals and issuing output signals. The axons are represented by interconnections of the nodes, and finally, the synapses of varying strength and character (exciting or inhibiting) are represented by weights (positive or negative) which multiply the signal.

The twofold function of the J^{th} neuron consists of

- i. Summing weighted signals from those neurons upstream of the node.

$$z_j = \sum w_{ji}y_i$$

where y_i is the signal arriving from node i .

- ii. Issuing an output signal $f_j(z_j)$.

Three types of activation functions $f(z)$ are customary:

- a. Step function

$$f(z) = 0, z < \Theta,$$

$$1, \Theta \leq z.$$

- b. Ramp function

$$f(z) = 0, z < \Theta,$$

$$z, \Theta \leq z < \Theta + 1,$$

$$1, \Theta + 1 \leq z.$$

- c. Sigmoid function

$$f(z) = 1/(1 + \exp(z - \Theta)).$$

Θ is a threshold or bias constant that may be "learned".

Learning Modes

The function of the network is to respond to the various input patterns by activating the output nodes in a desired manner. The nature of the "hidden" nodes and the weights assigned to their interconnections determine the responses and the selection of a successful combination, not necessarily or even likely to be unique, may be called a learning process. One may distinguish between unsupervised learning and supervised training. In either case, a network has two phases, a learning period and a productive period.

In supervised training, which we emphasize in this discussion, the two phases are strictly distinct. A set of training patterns and the required set of responses is presented to the network. By some "learning process," the weights, functions, and thresholds are adjusted whenever the output from a training presentation differs from the required result. The process is repeated until the errors are reduced to a tolerable level, at which time the training is complete and the system is ready to begin the production phase.

Several simplifications in the arrays of nodes and connections can aid in the analysis of a network and its training. One such simplification is to require a network to be layered. In the usual definition from the operations research literature, a layer consists of nodes connected only to any or all nodes in the immediately preceding and following layers, and to no other nodes. The XOR mentioned above is not layered because the input nodes are connected directly to the output node as well as to the intermediate hidden node. A layered network can solve XOR, as shown in Figure 3. The hidden units are connected to input and output layers but not amongst themselves, and there is no direct connection from input to output nodes.

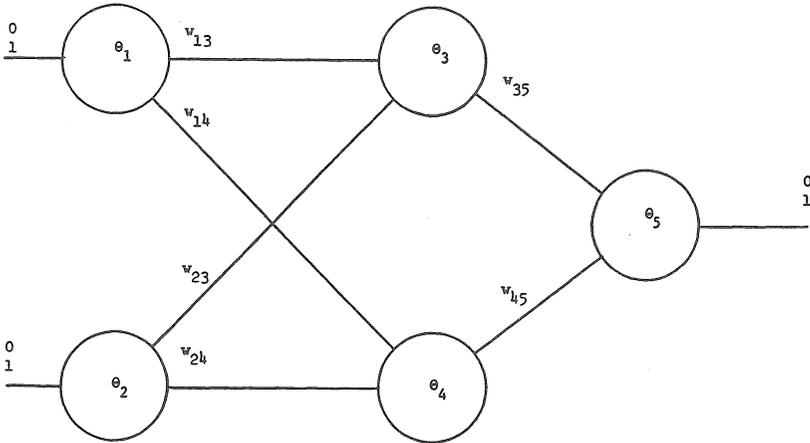


Fig. 3.

Backward Error Propagation

Of the various training models that have been proposed, the feed forward, layered network, with training by backward error propagation, provides an interesting problem in classical optimization, although it does not appear to be analogous to any biological process. A signal is presented to the input nodes and is propagated through the network. The difference between the output response and the desired response is the error. The squared error is summed over the input patterns that are to be learned. Minimizing this objective function by adjusting the network weights and bias values constitutes the training process.

When the activation function $y = f(z)$ satisfies the logistic differential equation, $y' = y(1-y)$, whose solution is the sigmoid function mentioned above, the error is easily propagated backwards through the network, thus providing an error value at each node. The back-propagation is carried out by successive application of the chain rule for differentiation, and the properties peculiar to the solution of the logistic differential equation. The consequence of the backward error propagation is a gradient of the objective function with respect to the parameters of the system. The steepest descent algorithm, notorious for its slow convergence, has been proposed to solve this problem and a number of acceleration procedures have been suggested with varying degrees of success.

Modelling the Biological Process

The Neural Network analog of the biological process seems to be rather crude and several authors criticize certain models, such as backward error propagation, for their lack of biological plausibility. While the implausible network may perform its appointed tasks in an acceptable manner, it may not be

useful in pursuing the biological analogy. Several models of unsupervised learning are more suited to the analogy. The software provided with McClelland and Rumelhart's third volume⁵ includes several of these models. At the extreme of this point of view, a very detailed description of the activities of real neurons and synapses may be quite accurate in its analogy but extremely difficult to solve, i.e., evaluate the parameters needed to construct a hardware device. The biological neural activity proceeds in a time scale of milliseconds, while memory (learned qualities) persists over hours, days, and years. These widely varying time constants constitute the numerical property of "stiffness" which requires special methods for solving the differential equations.

Potential Applications

Several attributes of the new technology have encouraged its development. One very conspicuous and important property is the insensitivity of performance level to perturbations in the network parameters. A computer working without human attention, such as aboard an unmanned space probe, could incur damage to its network without a total failure of its function, and indeed might relearn its forgotten tasks. Similar to a brain in this sense, an accident might be fatal, relatively harmless, or result in degraded but acceptable performance that may be partially restored by rehabilitation training.

Another characteristic of a biological nervous system is the ability to associate information. A collection of units, each with a set of attributes, forms a network with weighted arcs and a learning rule that seeks an equilibrium state. When a node is stimulated by an input or query, the network responds by adjusting to a new state of equilibrium in which appropriate attribute nodes are activated, thus producing an association with the query.

Still another useful natural behavior that may be imitated by an artificial neural network is decision making in the presence of error or noise. An example of such behavior is the recognition of an imperfectly printed letter within a line of type. This recognition of an imperfect replica of a learned example is easily performed by a neural network.

Artificial neural networks are also interesting in their own right and we may look forward to improved understanding of memory, learning, and communication as a result of research on our simplified models.

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Flexible Manufacturing Through Excellence an R & D Perspective

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Abstract: American manufacturing is learning that in order to survive it must compress the "concept to product" cycles. The Mission Statement of Orscheln R & D includes development of new products and processes within the flexible manufacturing arena. Development work is accomplished on production equipment with a mixture of mechanical engineers, chemists, and chemical engineers from R & D who work side-by-side with production personnel. The R & D lab consists of only basic analytical tools for observation and measurement. The design cycle is compressed through the elimination of scale-up. The manufacturer of tomorrow will continue to require flexing of not only manufacturing processes, but also management styles. The manager of tomorrow must embrace change in order to deal with the integration of electronic information systems and manufacturing systems without forgetting about people.

Key words: Flexible Manufacturing, Adaptation, Flexible Management Styles

Survival of the Fittest

Charles Darwin saw in this world of ours the unlimited multiplication of living creatures, however, the food supply is limited and so is the available living space in the world. The result is a life-and-death competition between all living things, an everlasting struggle for existence. Those that are best fitted to their environment are able to live, and the rest are doomed to die, rather simplistic but factual.

In the course of time, the environment keeps changing. During these changes, it becomes necessary for a response to the environment. "Natural selection" or "survival of the fittest" is the process in which nature selects those characteristics which enable the species to survive and elimination of those characteristics which are no longer necessary for survival in the new environment.

Darwin's work studied change and how species flexed in response to the environment. Likewise, American manufacturing must learn to be flexible in its manner of manufacturing in order to emerge as a winner in running the survival of the fittest gauntlet.

The industrial revolution turned manufacturing upside down, dispatched us from the journeyman apprentice relationship and spawned not only a revolution but also brought refinement of our form of merchantilism. My grandfather was particularly impacted by the industrial revolution. He was born in 1890 and shared with his grandchildren the awesome changes he saw during his lifetime all caused by the Industrial Revolution.

The most modern tool in his early years was a portable grist mill and a kerosine lantern on a small farm on the Cuivre River near Hawkpoint, Missouri. He told of his first train ride and his ocean voyage to France as part of the American Expeditionary Force under General Pershing. The changes he shared with me ranged from seeing the first car as a young man to watching biplanes in dogfights overhead in the trenches in the Argonne forest of France, to watching men walk on the moon. His generation perhaps witnessed more changes than any other in the history of the human race to date. But as we look around us people and businesses are resistant to change when change is the norm. If we are willing to look close enough, we will find within us a powerful resistance to change.

The revolution also spawned the ever expanding technology base that fuels our society. Many high technology products are in great demand world wide, but so far almost all of them come from a handful of industrial nations. These nations possess the necessary combination of resources including R & D Engineering skills, venture capital, and marketing know-how to compete in technology markets.

Every country finds it necessary to obtain technology in order to retain market shares and stay in the economic race, unlike earlier forms of international trade based predominantly on agriculture or mineral products linked to natural resources. As opposed to a large coal mine or seaport, technology is completely portable, it depends on the scientific capabilities and technical skills and surplus capital which can be developed anywhere.

R & D skills are mastered so the products can be adjusted to meet changing needs in the market place. They hold long-term promise for production of exported goods in high demand. This in turn equates to continued employment and usually a steady rising contribution to the economy. The key is not only accepting and implementing change, but also adopting flexible methods of manufacturing in order that machines and assembly lines of today can produce the products of tomorrow. All of this is to say that change is inevitable, and that designing in flexibility holds promise for optimizing the manufacturing process. Thereby enhancing productivity and improving the bottom line.

Organizational Design & Organizational Behavior Factors

Organization design factors that are precursors of successful flexible manufacturing include an expanded mission statement for R & D and flexible management styles.

Expanded Mission Statement

The R & D effort at Orscheln is vital for survival of the firm. As in most industrial organizations, we believe that the traditional role of R & D has been to develop new products and processes, but that role is changing to include protecting and improving the current products.

Orscheln R & D Mission Statement includes cutting cost, improving productivity as well as responding to safety, health, and environmental problems. Orscheln R & D is a mixture of Mechanical Engineers, Chemical Engineers and Chemists performing in all of these areas. Additional support is provided through the use of university professors, and industry professionals as consultants as well as the scientific and technical staff of major suppliers.

Since the group is many faceted, open discussions and problem solving sessions are aired frequently in stand-up meetings called to just draw in others as sounding boards. This arrangement stresses informal discussion that is issue directed. Open communications are essential for maintaining the flexible environment necessary for fruitful R & D work.

The orientation away from blue sky research to applied research requires R & D to be very much involved in the everyday activities of the company, no "arms length away" from manufacturing, but rather so close that at times it is difficult to draw a line between the two groups. The organizational design of R & D stresses the development of explicit objectives. Once the objectives are developed, individuals have considerable freedom to select how they will achieve those objectives.

The relationship between R & D and the other operating units have been adapted to this endeavor. Management has painted the shotgun white and married the R & D group to the manufacturing facilities. Manufacturing's primary objective is to establish a production line that continuously produces a product with specified quality and quantity. Once a production line is placed, manufacturing personnel typically resist the effort to change it. The purpose of R & D is precisely to change the line when a technical breakthrough is developed. R & D not only engenders change, but also utilizes production facilities for all development work. New technologies carry in the very seeds of destruction of the status quo. The ability of manufacturing to flex with new technologies is a measure of survivability.

To understand Orscheln's approach to integrating R & D into the line organization, one must understand organization structure. Orscheln is market driven and extremely market sensitive responding very rapidly to changes much like the weather vanes. As the wind of change blows through the marketplace, we can readily adapt to that new wind current and respond rapidly to customers needs.

The design cycle for R & D projects is compressed through elimination of scale-up through the integration of R & D into Manufacturing, as all development work is accomplished on production equipment. A side benefit derived through this integration is that the transfer of technology is enhanced through manufacturing personnel being involved in all experimentation. Additionally, R & D personnel are assigned to the factory until the processes are in control in manufacturing as the standard method for transferring technology.

Should the Darwin of today study the American manufacturing community, he would observe a varied response to environmental conditions. Some species are growing lethargic in their response to the market and indifferent to changes in technology; some are stuck in the maze of short term profit pressures, while others are in the death quiver of obsolescence. While some species are into quagmires of dated technologies, others are fat from artificial markets created by government intervention in a free market economy. Manufacturing species that change willingly, laying aside old behavioral patterns and fostering innovation in a climate of continued and rapid improvement; always striving for excellence, will be the survivors.

Indeed, "survival of the fittest" is not peculiar to the world of Darwin. American manufacturing is learning that in order to survive, it must compress the "concept to product" cycles. Tools available for that task include Just-In-Time

(JIT), Statistical Process Control (SPC), and Computer Integrated Manufacturing (CIM). These are under the umbrella of flexible manufacturing, but all of this must be undergirded by an "excellence" philosophy that reinforces a principle of continued refinement of all manufacturing processes.

Today's competitive business climate puts a premium on innovation and initiative which requires liberating the creativity of individuals. Organizations that encourage creativity will replace mature institutions, stimulate market driven enterprises, and keep pace with rapidly changing markets.

R & D in industry has never been more vital than today. We are faced with alarming trade deficits and a seemingly lack of industrial competitiveness. Perhaps we need to rethink our approach to designing; an approach that would teach excellence and within that excellence would bring a continuing refinement of the design cycle.

The manufacturer of tomorrow will continue to require flexing of not only manufacturing processes, but also management styles. The manager of tomorrow must embrace change in order to deal with the integration of electronic information systems and manufacturing systems without forgetting about people. The point can be made that if the very top levels of any human organization are resistant to change, such as support of an antiquated MRP system or outdated procedures, then they are in serious trouble. Hypocrisy can be so unquestioned, so frequently and piously repeated that it becomes a kind of twisted sincerity.

By the word "fittest" Darwin did not necessarily mean the strongest or the most ruthless, but the most adaptable. The R & D manager must create the environment in which innovation and opportunities are recognized, resources provided, and successes rewarded. The environment must be acceptable to R & D people and maintain a professional network through professional organizations, trade journals, and scientific papers. With the focus on unleashing potential, management must help employees structure their work activities, give feedback, provide evaluation, and essentially manage people to produce. The manager who focuses on releasing potential will be seen working for his employees, locating resources, providing assistance, and representing them to the rest of the organization.

Furthermore, excellence requires intimate relationships between R & D and Manufacturing as well as the Product Engineering groups. It is known that a well managed technology can be a powerful tool for corporate growth, while the price of mismanaging technology can result in the demise of the corporation. Likewise, the failure to practice excellence in relationship is the most crucial tool in the hands of managers. The organizational structure of Orscheln R & D is not the neatly stacked columns of boxes interconnected by vertical lines, but rather can be described as inter-connected circles with lines of communication and responsibility radiating in all directions.

Flexible Management Styles

The second major factor in implementing flexible manufacturing can be found in organizational behavior. Two events sensitized me to people problems. I understand that people do what they do because they are hurting. I have had several courses in clinical counseling and subsequently worked in the Missouri penal system as a counselor in the maximum security prisons; devoting two to four evenings a month caring for the scourge of our society. Within the prison

walls, I see the downward spiraling of men grieving over their past, acting out of not only grief, but also grieving over how they have acted out their past and not understanding what is driving them. My task is establishing within their minds the cause and effect relationships for their behavior. This has given me the insights into those who work for me. I can look into a prisoner's eyes and say, "I understand, I have been there" as I am a product of a very rough beginning.

The second event was a farm accident which two surgeries later left me with a hand that does not work well. A hand that used to build cabinets and taught 4-H wood-working classes, now does well to hold a pencil. This impediment has imparted a keen understanding of the halted, the handicapped and their struggles in life. I see those who are halted or handicapped emotionally and I have an understanding of their struggles.

Because of my work in the prison and the continued struggle with a hand that does not work well, I have gained a keen insight into why people do what they do. Simply, they do what they do because they are hurting. I understand the plight of the strained emotions, stretched relationships, exploitation, use, and control. I have thrown off the shackles of exploitation that were passed on to me and choose to embrace a philosophy of non-violence; not a new teaching, but rather an old teaching revisited and reproven.

Before I could be a manager of men, I must be a lover of men. I must be committed to their well being, no longer an arms length away in the traditional management style, locked away, unreachable, untouchable in perhaps a classic curmudgeon form. I saw that I must be a coach to forge a team.

Tools that I have used to accomplish that work includes celebration of individuals birthdays as a group, going to ball games as a family, attending science lectures at local universities, and supporting a flexed time program with no fixed work hours. I do not believe that highly creative people need to be reminded that a certain number of hours per week is expected. If they do, I have made a mistake by hiring them.

Rather, I teach and live excellence. This is done by continually refining what we are doing. We are trying constantly to improve and to compress so we can move quicker to the market place by continued refinement, and compression. We do this even in a simplistic way of mandating that in-baskets are emptied daily, thereby, ensuring the information flow within and without the group is enhanced. This ensures that there is no stagnant paper, no one waiting for an answer to make the next decision.

How does the manager hold up the demands for excellence while still wearing the sweatshirt that says "coach"? Quoting from the writings of the most widely read book of all General Managers:

"He that rules over men must be just. Ruling in the fear of God and he must be as the light of the morning when the sun rises." (II Samuel 23).

These were the last words spoken by David, King and Chief Executive Officer of the Tribal Confederacy of Israel.

Perhaps some day our business schools, colleges, and universities will likewise teach the principle of relationships. Then in order to be a leader of men you must be a lover of men. Some day they will teach that excellence can be attained if you care more than others think it is wise; to get involved with workers more than others think it may be prudent; risk more than others think it is safe;

and be more open than others may dream safe; dream and share those dreams more than others think it is practical; and expect more than others think it possible.

Biographical Sketch for Bob Heimann

- College:* Business Major with Columbia College
- Previous Employment:* Employed by McDonnell Douglas on the F-4 Phantom Project involving cockpit and equipment engineering for seven years, and on Skylab, (the first space station) for 1.5 years.
- Current Employment:* Employed by Orscheln Co. for 10.5 years. Currently Manager of Research and Development.
- Recent Scientific Accomplishment:* The Orscheln R & D group has developed the first application of ceramics on cables in the form of a corrosion inhibiting silicate coating; a major breakthrough in cable technology. The silicate coating is the product of an Applied Research Grant at Northeast Missouri State University that started as a dream with Bob five years ago and is now starting into full production.
- Hobbies:* Yard work and Little League Coach

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Polymers Via Michael-Type Additions to Bis(Ethynyl Ketones)

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Abstract: Aliphatic bis(ethynyl ketones) undergo a facile nucleophilic addition (Michael-type addition) polymerization with diamines and dithiols to afford poly(enamine-ketones) and poly(enonesulfides) respectively. The Friedel-Crafts reaction of bis(trimethylsilyl)acetylene (BTMSA) with adipoyl chloride and sebacoyl chloride followed by removal of the trimethylsilyl group with an aqueous basic buffer solution gave the new aliphatic bis(ethynyl ketones): 1,9-decadiyne-3,8-dione (3a) and 1,13-tetradecadiyne-3,12-dione (3b). The nucleophilic addition polymerization of these with diamines and dithiols proceeds readily at temperatures between 0° and 25°C to afford a new class of polymers that may be useful in two component adhesive and reaction injection molding systems. The configuration of the structure in the polymer backbone is dependent upon the structure of the nucleophilic monomer.

Key words: Aliphatic bis(ethynyl ketones), 1,9-decadiyne-3,8-dione, 1,13-tetradecadiyne-3,12-dione, poly(enamine-ketones), poly(enonesulfides)

Introduction

Aromatic bis(ethynyl ketones) have been shown to undergo nucleophilic addition polymerization with diamines and dithiols to afford high molecular weight poly(enamine-ketones) and poly(enonesulfides), respectively.¹ These polymerizations occur rapidly at temperatures as low as 0°C without the evolution of volatile materials. Bass and coworkers² have reported the synthesis of aromatic poly(enamine-ketones) by the Michael-type addition of various diamines to phenyl-terminated aromatic bis(ethynyl ketones) in *m*-cresol at 60-130°C. Bass' group has also shown that aromatic poly(enonesulfides) can be prepared by nucleophilic addition of various aromatic dithiols to the same phenyl-terminated aromatic bis(ethynyl ketones) in *m*-cresol at 25-40°C.³ The higher temperatures required for the polymerizations involving the phenyl-terminated bis(ethynyl ketones) versus the H-terminated aromatic bis(ethynyl ketones) reported by Harris and Beltz¹ is probably due to the steric hindrance exerted by the terminal phenyl group to the nucleophilic addition of the diamine and dithiol. Since aliphatic bis(ethynyl ketones) were unknown when this work was initiated, it was desirable to develop a new synthesis for these monomers and examine their polymerization with diamines and dithiols.

Results and Discussion

Bis(trimethylsilyl)acetylene (BTMSA) has been reported to undergo a Friedel-Crafts reaction with acyl chloride/aluminum chloride complexes to afford high

yields of trimethylsilylethynyl ketones.³ Treatment with aqueous methanolic $K_2CO_3/KHCO_3$ or borax solutions quantitatively removes the trimethylsilyl group to afford the corresponding ethynyl ketones.^{4,5} When applied to the readily available adipoyl chloride (1a) and sebacoyl chloride (2a), this approach successfully afforded the trimethylsilyl substituted intermediates (2a,b). Treatment of these with an aqueous $K_2CO_3/KHCO_3$ buffer solution gave the bis(ethynyl ketones) (3a,b) as illustrated in the following equation and Table 1.

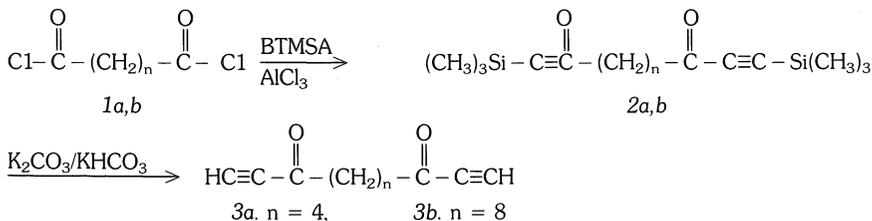
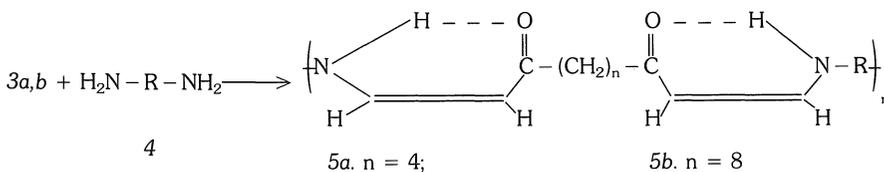


Table 1. Synthesis of Bis(Ethynyl Ketones)

Compound	Yield (%)	MP (°C)	Compound	Yield (%)	MP (°C)
2a	78	73-74.5 ^a	3a	75	67-68 ^b
2b	98	oil	3b	56	55-56 ^c

^aLit.⁸ mp 64-65°C; ^bLit.⁸ mp 60-61°C; ^cLit.⁸ mp 45-46°C

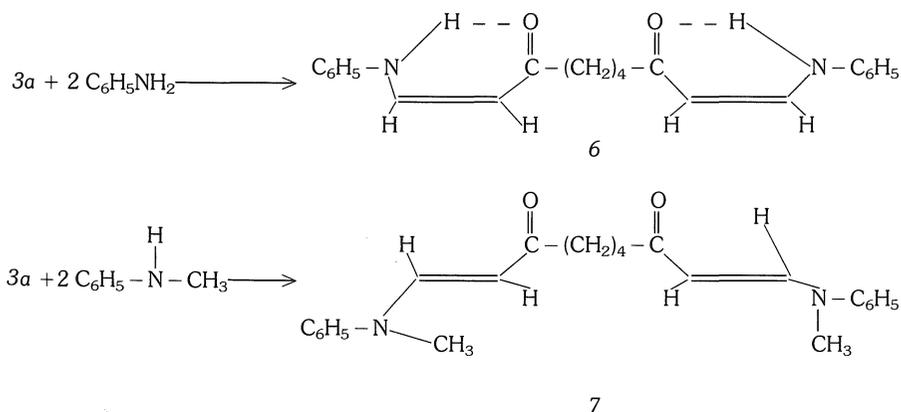
The poly(enamine-ketones) 5a,b resulting from the polymerization of 3a,b with primary aromatic diamines were only soluble in *m*-cresol which precluded the use of ¹H-NMR analysis to determine the stereochemistry of the enamine-ketone moiety in the polymer backbone. However, the primary aliphatic diamine, 1,12-diaminododecane (4, R = (CH₂)₁₂) gave a poly(enamine-ketone) (5a) with 3a that was soluble in chloroform. The ¹H-NMR analysis performed in CDCl₃ indicated that all of the enamine-ketone moieties were in the *cis*(*z*)-configuration (*J* = 8 Hz) as illustrated in the following equation. This evidence



suggests that primary aromatic diamines would also be expected to yield polymers with the *cis*(*z*)-configuration. In fact, Bass and co-workers have demonstrated that primary aromatic diamines react with aromatic bis(ethynyl ketones) to give predominantly enamine-ketones with the *z*-configuration.² Thus, it appears

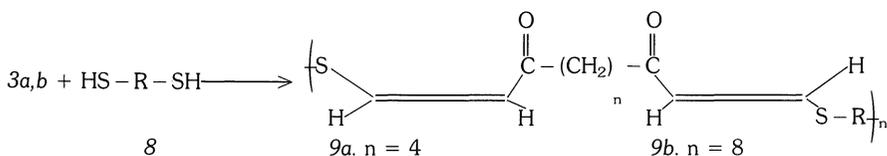
that the presence of intramolecular hydrogen bonding favors the formation of the *cis(z)*-configuration in polymerizations using DMF and *m*-cresol as solvents. Additional evidence supporting this hypothesis was obtained from the reaction of **3a** with aniline using DMF and *m*-cresol as solvents. The $^1\text{H-NMR}$ spectrum of the bis(enamine-ketone) (**6**) exhibited the presence of the vinyl protons in the *cis(z)*-configuration ($J = 8$ Hz). The bis(enamine-ketone) (**7**) formed by reaction of **3a** in DMF and *m*-cresol with *N*-methylaniline gave a $^1\text{H-NMR}$ spectrum showing the presence of the vinyl protons in the *trans(E)*-configuration ($J = 13$ Hz).

In the latter case intramolecular hydrogen bonding is precluded and the



trans-isomer would be expected to predominate.

Polymerization of aliphatic bis(ethynyl ketones) **3a,b** with dithiols (**8**) gave poly(enonesulfides) (**9a,b**) as shown in the following equation. The polymer from 2-mercaptoethyl ether was soluble in chloroform. The $^1\text{H-NMR}$ analysis



performed in CDCl_3 indicated that approximately 80% of the enonesulfide moieties were in the *cis(z)*-configuration ($J = 10$ Hz) and 20% in the *trans(E)*-configuration ($J = 15$ Hz).

Subsequent to the report of this work,⁷ Harris and coworkers,⁸ in an independent study, presented similar results on the polymerization of **3a,b** with a series of diamines and dithiols using *m*-cresol as the solvent.

Experimental

Bis(trimethylsilyl)acetylene obtained from Petrarch Systems was distilled before use as was adipoyl chloride and sebacoyl chloride. Aldrich 99.99% AlCl_3

was used. The *m*-cresol was vacuum distilled before use as was *N,N*-dimethylformamide (DMF) after drying over CaH_2 . The 4,4'-diaminodiphenylmethane was recrystallized from benzene to give colorless crystals, mp 93-94°C. The 1,4-diaminobenzene was recrystallized from benzene and sublimed to give colorless crystals, mp 141-143°C. The 2-mercaptoethyl ether obtained from Aldrich was redistilled (bp 64-5°C/2 mm). The 1,3-benzenedithiol was 99% grade and used as received from Aldrich. Elemental analyses were performed by Gailbraith Laboratories, Knoxville, Tennessee. A Varian Model 360-60 MHz instrument was used to obtain the NMR spectra. The IR spectra were determined with an IBM-FTIR-44 and a Perkin-Elmer Model 283 infrared spectrometer.

1,10-Bis(trimethylsilyl)-1,9-decadiyne-3,8-dione (2a). A solution of adipoyl chloride (18.3 g, 0.1 mol) and bis(trimethylsilyl)acetylene (37.5 g, 0.22 mol) in 50 mL of dry methylene chloride was added during 1 h to a stirred slurry of AlCl_3 (29.3 g, 0.22 mol) in 200 mL of dry methylene chloride under nitrogen while maintaining the temperature between 3-5°C. The reaction mixture was stirred under nitrogen at ambient temperature for 3 h, then poured into a 50/50 mixture of 500 mL of 10% HCl-ice. The organic layer was separated and the aqueous layer was extracted with methylene chloride (2×100 mL). The organic layers were combined, washed with water (2×100 mL), then with cold saturated NaHCO_3 solution (3×75 mL), and finally with 100 mL of water. The methylene chloride solution was dried with anhydrous magnesium sulfate, filtered, and the methylene chloride was removed *in vacuo* at 40°C to give 30.6 g (100%) of a dark solid. Two recrystallizations from hexane gave 23.92 g (78%) of almost colorless needles, mp 73-74.5°C; ^1H NMR (CCl_4) δ 0.2 (s, 9H), 1.5 (m, 2H), 2.3 (t, 2H). A third recrystallization from hexane using Nuchar afforded an analytical sample of colorless needles, mp 73-74.5°C (lit.⁸ mp 64-65°C). Anal. Calcd for $\text{C}_{16}\text{H}_{26}\text{Si}_2\text{O}_2$: C, 62.69; H, 8.55. Found: C, 62.59; H, 8.38.

1,14-Bis(trimethylsilyl)-1,13-tetradecadiyne-3,12-dione (2b). This was prepared in a similar manner by addition of a solution of sebacoyl chloride (11.95 g, 0.05 mol) and bis(trimethylsilyl) acetylene (19.0 g, 0.11 mol) in 20 mL of dry methylene chloride to a stirred slurry of AlCl_3 (14.66 g, 0.11 mol) in 100 mL of dry methylene chloride. A similar work-up procedure gave 18.7 g (100%) of crude product. Chromatography on a silica gel column using hexane and finally chloroform gave, after removal of solvent *in vacuo*, 17.7 g (97.6%) of a straw colored liquid which was sufficiently pure for desilylation; ^1H NMR (CCl_4) δ 0.2 (s, 9H), 1.3 (bm, 6H), 2.3 (t, 2H); IR(film) 1670 cm^{-1} (C=O), 2140 cm^{-1} (C=C), 1250, 860, 760 cm^{-1} [$(\text{CH}_3)_3\text{Si}$].

1,9-Decadiyne-3,8-dione (3a). To a stirred solution of *2a* (6.12 g, 0.02 mol) in 50 mL THF, was added dropwise 50 mL of 6.2×10^{-3} M $\text{K}_2\text{CO}_3/\text{KHCO}_3$ buffer solution while maintaining the temperature between 3-5°C by means of an ice bath. The addition required 35 minutes, during which time an additional 25 mL of THF was added to maintain a homogeneous solution. The mixture was stirred an additional 15 minutes at pH 7.5-8.0 and then acidified with cold 2 N HCl. After removal of about half of the THF *in vacuo* at 40°C, the residue was poured into 250 mL of cold water. The solid that precipitated was collected, washed well with water, and dried under vacuum in a desiccator to afford 2.65 g (82%) of light tan crystals, mp 65-68°C. Recrystallization from hexane using Nuchar gave 2.43 g (75%) of shiny plates, mp 67-68°C (lit.⁸ mp 60-61°C); ^1H

NMR (CDCl_3) δ 3.3 (s, 1H), δ 2.6 (t, 2H); IR (KBr) 3240 cm^{-1} ($\text{C}\equiv\text{C-H}$), 2100 cm^{-1} ($\text{C}\equiv\text{C}$), 1680 cm^{-1} ($\text{C}=\text{O}$). Anal. Calcd for $\text{C}_{10}\text{H}_{10}\text{O}_2$: C, 74.06; H, 6.21. Found: C, 74.15; H, 6.09.

1,13-Tetradecadiyne-3,12-dione (3b). A stirred solution of *2b* (3.63 g, 0.01 mol) in 50 mL of methanol was treated with 24 mL of $6.2 \times 10^{-3}\text{ M}$ $\text{K}_2\text{CO}_3/\text{KHCO}_3$ buffer in a similar manner during 0.5 h at $0\text{-}5^\circ\text{C}$. Additional buffer solution was added to give a pH = 7.5-8.0. After stirring 0.25 h, the mixture was acidified with cold 2 N HCl and poured into an equal volume of water. The solid that precipitated was collected by suction filtration and washed with water and dried under vacuum in a desiccator to give 1.8 g (82.5%) of a light tan solid, mp $51\text{-}53^\circ\text{C}$. Recrystallization from hexane using Nuchar gave 1.22 g (56%) of light tan plates, mp $55\text{-}56^\circ\text{C}$ (lit.⁸ mp $45\text{-}46^\circ\text{C}$); ^1H NMR (CDCl_3) δ 3.2 (s, 1H), δ 2.4 (t, 2H), δ 1.3 (bm, 6H). Anal. Calcd for $\text{C}_{14}\text{H}_{18}\text{O}_2$: C, 77.75; H, 7.45. Found: C, 76.86; H, 8.06.

Polymerization of Aliphatic Bis(Ethynyl Ketones) with Diamines. Poly(enamine-ketones) were prepared by polymerization of aliphatic bis(ethynyl ketones) (*3a,b*) with a series of diamines as summarized in Tables 2 and 3. The polymerizations were carried out under N_2 in *N,N*-dimethylformamide (DMF) or DMF/*m*-cresol solutions with 15% solids content using stoichiometric amounts of monomers. After one hour at $0\text{-}5^\circ\text{C}$, the viscous reaction mixtures were stirred at ambient temperature for periods of 18-22 h. The polymers were isolated in almost quantitative yield by precipitation from stirred solutions of 50% ethanol/water. The polymers were washed with water, methanol and finally ether and dried 24 h under vacuum in a desiccator at room temperature. Aromatic diamines gave poly(enamine-ketones) that were soluble only in *m*-cresol. These polymers are semi-crystalline yellow solids.

Polymerization of Aliphatic Bis(Ethynyl Ketones) with Dithiols. The poly(enonesulfides) produced by the polymerization of dithiols with the aliphatic bis(ethynyl ketones) (*3a,b*) are listed in Tables 2 and 3. The polymerizations

Table 2. Polymerization of $\text{HC}\equiv\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-(\text{CH}_2)_4-\overset{\text{O}}{\parallel}{\text{C}}-\text{C}\equiv\text{CH}$

Diamine	Solvent	Time (hrs)	n^a
4,4'-diaminodiphenylmethane	DMF/ <i>m</i> -cresol 25/1	22	0.14
4,4'-diaminodiphenylmethane	DMF	19	0.11
1,4'-diaminobenzene	DMF	18	0.73
1,12-diaminododecane	DMF/ <i>m</i> -cresol 3/1	19.5	0.24
Dithiol			
1,3-benzenedithiol	<i>m</i> -cresol	14	1.51
2-mercaptoethyl ether	<i>m</i> -cresol	20	0.36

^aInherent viscosity determined in *m*-cresol with a concentration of 0.5 g/dL at 25°C .

Table 3. Polymerization of $\text{HC}\equiv\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-(\text{CH}_2)_8-\overset{\text{O}}{\parallel}{\text{C}}-\text{C}\equiv\text{CH}$

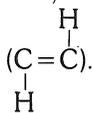
Diamine	Solvent	Time (hrs)	η^a
4,4'-diaminodiphenylmethane	DMF	20	0.19
1,4-diaminobenzene	DMF	22	0.57
1,4-diaminobenzene	m-cresol	3	insol.
Dithiol			
1,3-benzenedithiol	m-cresol	19	2.21
2-mercaptoethyl ether	m-cresol	22	0.41

^aInherent viscosity determined in m-cresol with a concentration of 0.5 g/dL at 25°C.

were carried out under N_2 in m-cresol solutions with 15% solids content using stoichiometric amounts of monomers. The polymerizations were initially conducted for 2 h at 0-5°C and then allowed to continue at ambient temperatures for 14-22 h. The polymers were isolated by precipitation from stirred solutions of methanol and washed with methanol and ether and dried 24 h under vacuum in a desiccator at room temperature. Except for 2-mercaptoethyl ether, the poly(enonesulfides) were formed in nearly quantitative yield. The poly(enonesulfides) prepared from 1,3-benzenedithiol had the highest inherent viscosities (1.51 and 2.21 dL/g) and were fibrous solids that were soluble only in m-cresol. Tough, flexible films were cast from chloroform solutions of the 2-mercaptoethyl ether polymer.

Model Bis(Enamine-Ketone) (6). Aniline (0.9313 g, 0.01 mol) was added to a solution of **3a** (0.8110 g, 0.005 mol) in 10 mL of m-cresol or DMF under N_2 at 0°C. The reaction mixture was stirred 0.5 h at 0°C and then at ambient temperature for 20 h. The product was isolated by precipitation from 50% ethanol/water and collected by suction filtration and washed well with water. Drying overnight under vacuum in a desiccator afforded a yellow solid. The bis(enamine-ketone) obtained using m-cresol as solvent was recrystallized from dimethoxyethane to give 0.90 g (52%) of a yellow solid, mp 165-167°C; ^1H NMR ($\text{CDCl}_3/\text{m-cresol}$) δ 5.2 (d, $J = 8$ Hz, 1H); IR (KBr) 1672 cm^{-1} ($\text{C}=\text{O}$), 1647 cm^{-1} ($\text{C}=\text{C}$). The bis(enamine-ketone) obtained using DMF as solvent could not be purified by recrystallization but gave identical ^1H NMR and IR spectra.

Model Bis(Enamine-Ketone) (7). This was prepared similarly from **3a** (0.8110 g, 0.005 mol) and N-methylaniline (1.0716 g, 0.01 mol) using 10 mL of m-cresol or DMF as solvents. Both solvents gave the identical bis(enamine-ketone) (**7**). Recrystallization from hexane/benzene, followed by drying overnight (61°C/0.1 mm Hg), afforded a pale yellow crystalline solid, mp 110-111.5°C; ^1H NMR (CDCl_3) δ 5.4 (d, $J = 13$ Hz, 1H), δ 7.9 (d, $J = 13$ Hz, 1H); IR (KBr) 1653 cm^{-1} ($\text{C}=\text{O}$), 983 cm^{-1}



Acknowledgement

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Missouri Carex Notes 3. A *Carex* Hybrid New to Missouri

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Abstract: The first report in Missouri of a natural hybrid between *Carex laeviconica* and *Carex trichocarpa* is made. The hybrid occurs in a northwestern Missouri prairie remnant and shows intermediate characteristics between its putative parents. It is most easily separated from either parent by a somewhat reddened and slightly fibered ventral sheath.

Key words: *Carex* section *Paludosae*, *Carex laeviconica*, *Carex trichocarpa*, prairie, Missouri

Introduction

According to Steyermark (1963), *Carex* section *Paludosae* is represented in Missouri by the following six species: *Carex lacustris* Willd. (several counties north of the Missouri River), *C. hyalinolepis* Steudel (throughout Missouri except for much of the Ozark Plateau and Northern border counties), *C. x subimpressa* Clokey (Clinton and Lewis Counties north of the Missouri River and Bates County south of the Missouri River), *C. atherodes* Spreng. (Jackson and Mercer Counties), *C. laeviconica* Dewey (mostly north of the Missouri River), and *C. trichocarpa* Schkuhr (Maries and Reynolds Counties). Members of the section are generally large plants of hydric-mesic habitats. Most populations are in no danger of extirpation except for the colony of *Carex x subimpressa* in Clinton County. It is small and in a vulnerable site along the shoulder of a county road (Castaner, 1986). The states of this hybrid in Lewis and Bates Counties are not known.

Methods

In the course of a study of the sedges of Missouri, a colony of an unidentifiable sedge was found in a depression in the Three-Mile Prairie, a remnant prairie strip north of Pickering in Nodaway county. This long prairie, preserved because it lies between State Highway 148 and an old Burlington Northern railroad track, was selected for investigation because of its relatively undisturbed state. In addition, a very rare Missouri sedge, *C. sartwellii* Dewey had previously been found there (Castaner, 1982). Specimens, Castaner 5690, 1 June 1979, and Castaner 5749, 7 June 1979, were collected in section 35

T66N R35W just south of the Hundred-And-Two River, examined, identified, and forwarded to A. A. Reznicek at the University of Michigan for further examination.

Results and Discussion

Castaner 5749 and *Castaner 5690* resemble plants Reznicek has seen from the midwest from Wisconsin south through much of western Illinois and eastern Iowa. Based on field studies in Illinois and herbarium work by him, the Nodaway colony is apparently the hybrid *C. laeviconica* × *C. trichocarpa*.

Although similar in overall appearance, *C. trichocarpa* and *C. laeviconica* differ in a number of details. The perigynia of *C. trichocarpa* are pubescent whereas those of *C. laeviconica* are glabrous. Also the achenes of *C. trichocarpa* are usually obovoid-trigonus whereas those of *C. laeviconica* are usually rhomboidal. The uppermost sheaths of *C. trichocarpa* are strongly reddened (Fig. 1D.) and not fibrillose whereas those of *C. laeviconica* are pale brown and strongly fibrillose (Fig. 1A.).

The hybrids are intermediate in these respects: the perigynia are sparsely pubescent, the (empty) achenes are intermediate in shape, and the sheaths are somewhat reddened with veins clearly visible but not strongly fibrillose (Figs. 1B, 1C). Some hybrid populations resemble one of the parent species more than the other and backcrosses are apparently involved. The hybrids are usually vigorous and form large clonal colonies. Neither putative parent may be found growing nearby.

Of the parents, *C. laeviconica* has been recorded from Nodaway county and several nearby counties, while *C. trichocarpa* is relatively rare in Missouri and is reported only south of the Missouri River in Maries and Reynolds counties (Steyermark, 1963). Of the hybrids formed by *C. laeviconica*, *C. trichocarpa* is most likely to be the other parent. The hybrid somewhat resembles the elusive *C. caesariensis* of Mackenzie (1931) which Reznicek and Catling (1985) consider most probably to be a hybrid between *C. trichocarpa* and *C. lanuginosa* Michx. This latter hybrid has not been recorded in Missouri.

A short description of the specimens is given: Culms and leaves to 95 cm long; leaves 5-6 mm wide, septate-nodulose at their bases; dorsal sheath septate-nodulose; culm 5-9 mm wide just above crown; ventral sheath apex concave; reddened at the slightly thickened edge; the vee-shaped wine-red area continuing downwards centrally, with evident somewhat pinnately distributed fibers, these not evident in shredded sheaths; rhizomes long, to 2.5 mm wide, with internodes to 2.5 cm; up to 4 staminate spikes present; up to 4 pistillate spikes, to 11 cm long and 6 mm wide; perigynia coriaceous, 5-8 mm long, ovate, somewhat hispidulous, rib thick and pronounced; teeth 1.5 mm long from point of divergence at tip of perigynium; scales to 6 mm long, acute and awned.

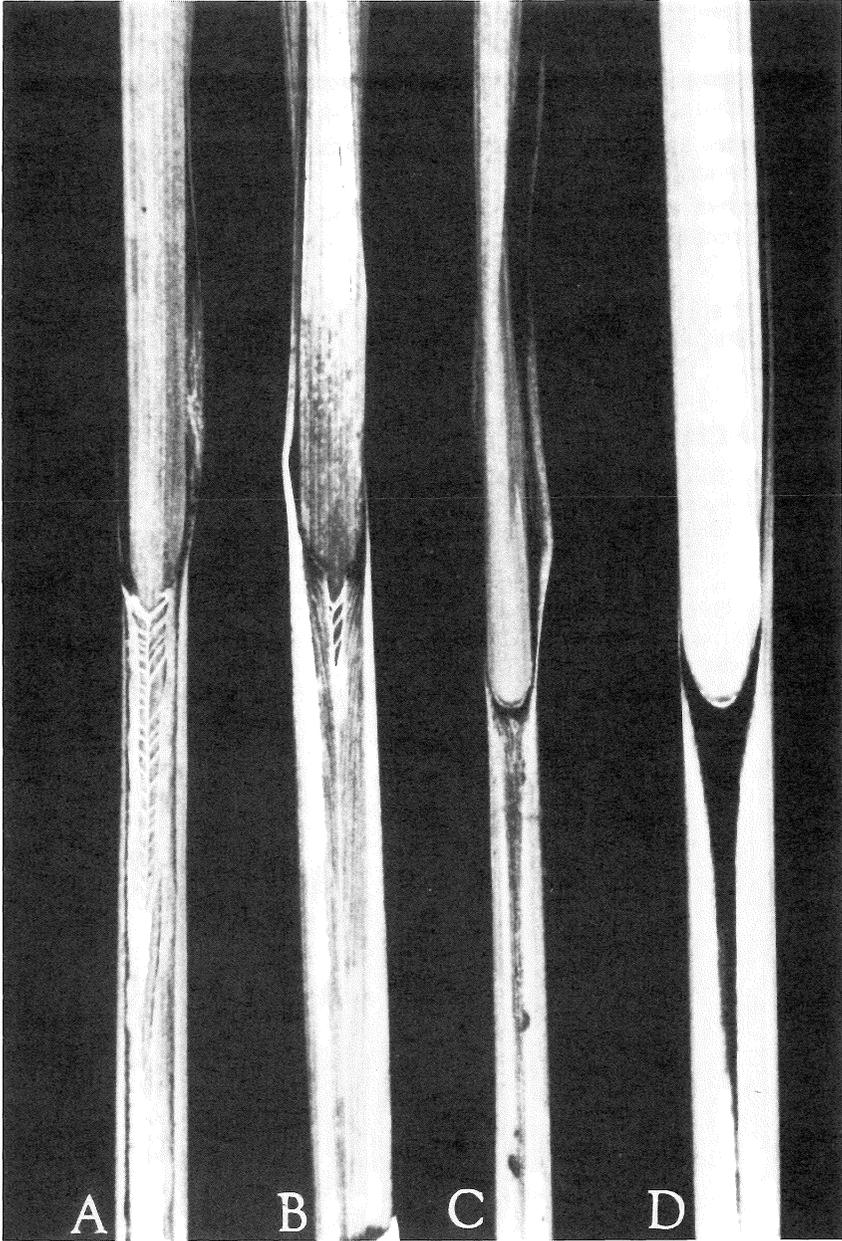


Fig. 1. A. Ventral sheath of *Carex laeviconica* Dewey; B. & C. Ventral sheath of *Carex* putative hybrid of *C. laeviconica* × *C. trichocarpa*; D. Ventral sheath of *C. trichocarpa* Schkuhr.

The following addition to the key on page 317 of the Flora of Missouri (Steyermark, 1963) will help one identify this hybrid:

- ×. Perigynia 5-10 mm. long; pistillate spike 8-15 mm. thick; faint or prominent raised lines or ribs showing on surface of perigynia × ×
- × ×. Ventral sheath veins becoming filamentous, sheath apex somewhat reddened *C. laeviconica* × *C. trichocarpa*
- × ×. Veins of ventral sheath not filamentous, except rarely at base, sheath apex much reddened y (to *C. trichocarpa* and *C. × subimpressa*)

Voucher specimens of *Castaner 5749* are in the Herbaria at Central Missouri State University [WARM] and University of Michigan [MICH]; *Castaner 5690* is at WARM.

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Using Two Levels of Parallelism in Solving an Integer Linear Programming Problem

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Abstract: A parallel integer linear programming algorithm involving two levels of parallelism was implemented on the Encore Multimax and the Sequent Balance multiprocessor computers. A comparison is made using the simplex calculation as the module of parallelism versus including the calculation of a single row of a pivot operation as the module of a second level of parallelism. For a given number of processes, it is shown that including the row operation module gives better utilization of the processors.

Key words: Integer Linear Programming, Parallel Algorithm

Introduction

In a previous paper,¹ we described a parallel algorithm which used branch and bound techniques for solving integer linear programming problems. The purpose of that paper was to show that it is possible for the number of pivots necessary to calculate the solution for an integer linear programming problem could be reduced by using a multiprocessor computer. That algorithm involves operations on simplex tableaus which represent the nodes in a branch and bound tree structure. In search of an optimal solution, calculations for one node often lead to generation of two new nodes as its children. At the beginning of the branching, the processor utilization is quite low when several processors are used.

We describe a new algorithm which uses a second level of parallelism inside the pivot operation to increase the utilization of processors and hence improve total time.

Technique

The integer programming technique used is the First Fraction-Largest Present Upper Bound with the Lex-Column Dual Simplex.²

The parallel algorithm follows:

Calculate the simplex for the continuous solution

IF the solution is integer THEN
 problem is done

ELSE

 create the processes

 place the continuous node in the problem pool

 WHILE there is an unprocessed node in the pool

 Mark the node as being processed

 Copy the node

 Add the up row to the copy of the node

 Add the down row to the node

 Calculate the down node

 Check for fathoming (i.e., no solution or solution less than
 present lower bound)

 Put the down node in the pool of problems

 Calculate the up node

 Check for fathoming

 Put the up node in the pool of problems

 END WHILE

The calculation of the up or down node involves a set of pivot operations performed on the simplex $a(i,j)$. These are as follows:

(P1) Find the row with the most negative constraint constant, call it L (for Leaving variable);

(P2) For the columns in that row with negative elements find the quotients of the cost coefficients and the negative elements. The element which has as its quotient the smallest absolute value is called the pivot element, call this column E (for Entering variable).

(P3) The pivot operations are given by the following statement:

 For all i and for j not equal to E,

$$a(i,j) = a(i,j) - a(i,E) * a(L,j) / a(L,E),$$

$$a(L,E) = -1.$$

These pivot operations are done until there are no remaining negative constraint constants or infeasibility occurs. In either case, the simplex (node) is solved and if the solution is not integer, the problem is broken into two subproblems by adding constraint inequalities based on the first fractional value. This creates two new nodes (simplexes), each of which has a negative value (step P1) for the added row.

The processes communicate at the completion of each pivot operation to see if it is necessary to continue by a comparison with the current bound. The number of pivots necessary to complete a simplex (node) is determined by the number of nonzero elements in column E.

Since the pivot operations represent a substantial percentage of the work in the algorithm, we have attempted to speed up that portion of the algorithm by employing parallel techniques at the pivot level.

The pivots on a node must be done in sequential order, so we looked for a task within the pivot operation which could be parallelized. Not only did we need a parallelizable task, we also had to take into consideration the granularity of the task (how many operations were to be given to the task).

Our approach has been to spawn processes within the node processes each of which performs the row operations for an entire row of a tableau (P3 for a particular *i*).

When a row process has completed operations for one row, it may begin working on a second row in the same simplex if available. This approach supports the ability to remain independent of the number of processes devoted to simplex operations. Thus, a single process can perform all pivot calculations on an entire simplex if necessary.

At the beginning of the program, two integers are read. One integer indicates how many processes are to be used for node calculation and the other indicates how many processes are to be devoted to performing pivot row operations (the node process becomes one of the pivot processes and may calculate the entire simplex if no other pivot processes are available).

First the number of node processes will be spawned. Each process enters a monitor to request work to do. Initially, there is no work, so the processes are placed on a queue waiting for work. When the algorithm progresses to a point at which a node process is ready to perform a pivot operation, the number of row processes specified is created and placed in a queue. They will be removed from the queue, one at a time, and given a row of the current simplex tableau to process. However, for the row processes, as long as the number of rows of the simplex is as large as the number of row processes, there will be almost no waiting. Thus the total number of processes in existence at any one time may be as large as the product of these two numbers.

All of the coordination and synchronization of processes is done through the use of the ASKFOR monitor, as described in.³ A separate monitor is devoted to each of the levels of parallelism described above (calculation of a row of a pivot operation or a complete problem calculation).

The problem chosen is a system design problem which is well known⁴ and although small (14 variables and 9 constraint inequalities), takes 501 pivots on a single processor to reach the solution. With the original algorithm we were able to cut this to 459 pivots using 20 processors. Although this is a considerable work savings, it did not gain linear speedup. In the original algorithm one reason for the lack of speedup was the time spent by the processes waiting for an available processor, especially at the beginning of the problem.

Table 1 shows that the optimum time was with 4 processes assigned to nodes and 16 assigned to row operations. This is surprising, as the number of pivots was 506, which is larger than needed with one process. Also, this is a total of up to 64 possible processes on the 20 processor machine. With 16 processes assigned to nodes and 1 assigned to row operations, the time was 19 seconds and the number of pivots was reduced to 459.

A time degradation occurred when the number of total processes greatly

exceeded the number of processors. For example, when there were 256 processes (16 by 16) possible for the 20 processors, the time was 82 seconds. The degradation is to be expected, as 256 processes on 20 processors guarantees considerable queuing for some processes.

Table 1. Encore Multimax with 20 processors

The number of processes assigned to row operations (time in seconds) is across the top and the number of processors assigned to nodes is on the left.

	1		2		4		8		16	
	pivots	time								
1	501	24	501	15	501	10	501	8	501	7
2	511	21	501	12	501	7	501	5	502	4
4	502	21	497	11	504	7	501	4	506	3
8	498	21	503	11	487	6	499	4	491	17
16	459	19	477	11	470	6	469	9	503	82

Conclusions

Although linear speedup was not realized by our new algorithm, a much better utilization of the processors did take place.

It could easily be argued that this approach should be altered to place all processes under the control of a single monitor. Then, when a piece of work (at either level) becomes available, any ready process could handle it.

If implementing the algorithm for production, we probably would have taken the alternative approach. We have elected not to do so at present, however, because our present approach makes it easier to devote a given number of processes to a particular level. Thus, we were able to analyze the effects of parallelism at each level.

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An Unusual Occurrence of Conulariids in the Middle Mississippian of Eastern Missouri

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Abstract: *Paraconularia subalata* (Hall) is present in a beige, fine-grained limestone near the top of the Salem Limestone in a quarry at St. Charles, Missouri. It is found in association with the brachiopods *Camarotoechia mutata* (Hall), *Spirifer pellaensis* Weller, *Dictyoclostus* sp., and *Eumetria* sp.; fenestellid and ramose bryozoans; and an unidentifiable gastropod. More importantly, this conulariid and associated marine invertebrates also occur with abundant remains of the nonmarine plant fossil *Valmeyerodendron triangularifolium* Jennings. *Camarotoechia* is interpreted to have been an onshore, marine organism. *Spirifer* is assigned to a marine, shelf environment. *Valmeyerodendron* was terrestrial. *Paraconularia* probably was not transported far and thus, must have lived in a shallow, marine onshore environment. Its association with the lycopod *Valmeyerodendron* is due to the vagaries of transport and onshore habitat.

Key words: Conulariids - unusual occurrence - Middle Mississippian - Missouri

Introduction

Recent renewed interest in the study of conulariids is the result of the discovery of new forms, of better and uniquely preserved specimens, and of new associations, both organic and inorganic. In the past the conulariids have been variously classified as worms, mollusks (cephalopods, pteropods, and other mollusks), medusoid cnidarians, protochordates, and conodonts (Feldman and Babcock, 1986).

Conulariids have been found in many kinds of normal marine deposits, including shales, fine and coarse-grained limestones, siltstones, and sandstones, where they occur uncommonly with sponges, medusoid and rugose corals, brachiopods, bryozoans, worms, pteropods, cephalopods, other mollusks, echinoderms, arthropods, protochordates, and various microfossils. They are abundant in some special settings, such as iron-ore beds and phosphate-rich, highly carbonaceous black shales. Some of these shales also contain plant remains, which usually are poorly-preserved. The Salem conulariids occur abundantly in a fine-grained limestone, an unusual situation.

The conulariid specimens examined for this study occur in a beige, fine-grained limestone, which forms the top bed of the Salem Limestone in the St. Charles Stone Company quarry at St. Charles, Missouri (Figs. 1 and 2).

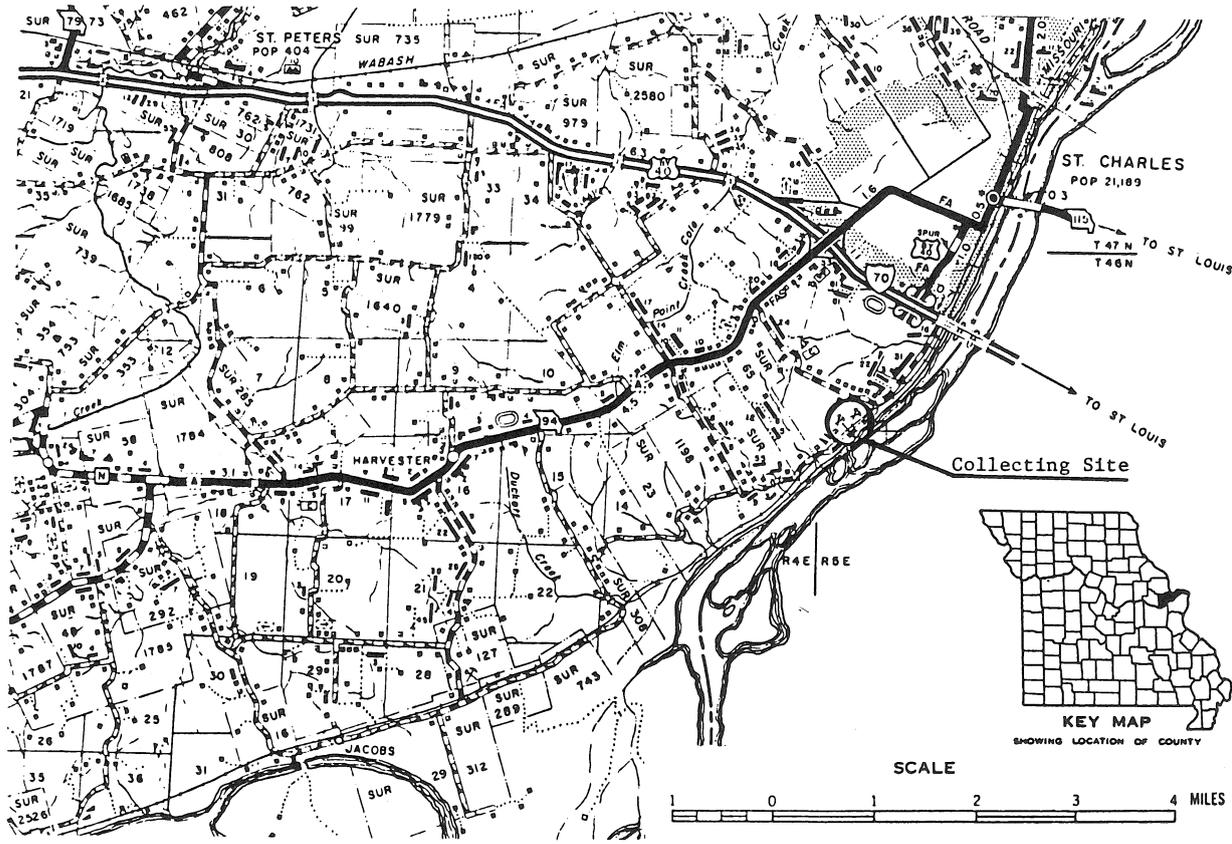


Fig. 1. Locality map showing St. Charles, Missouri, area and the collecting site (circled).

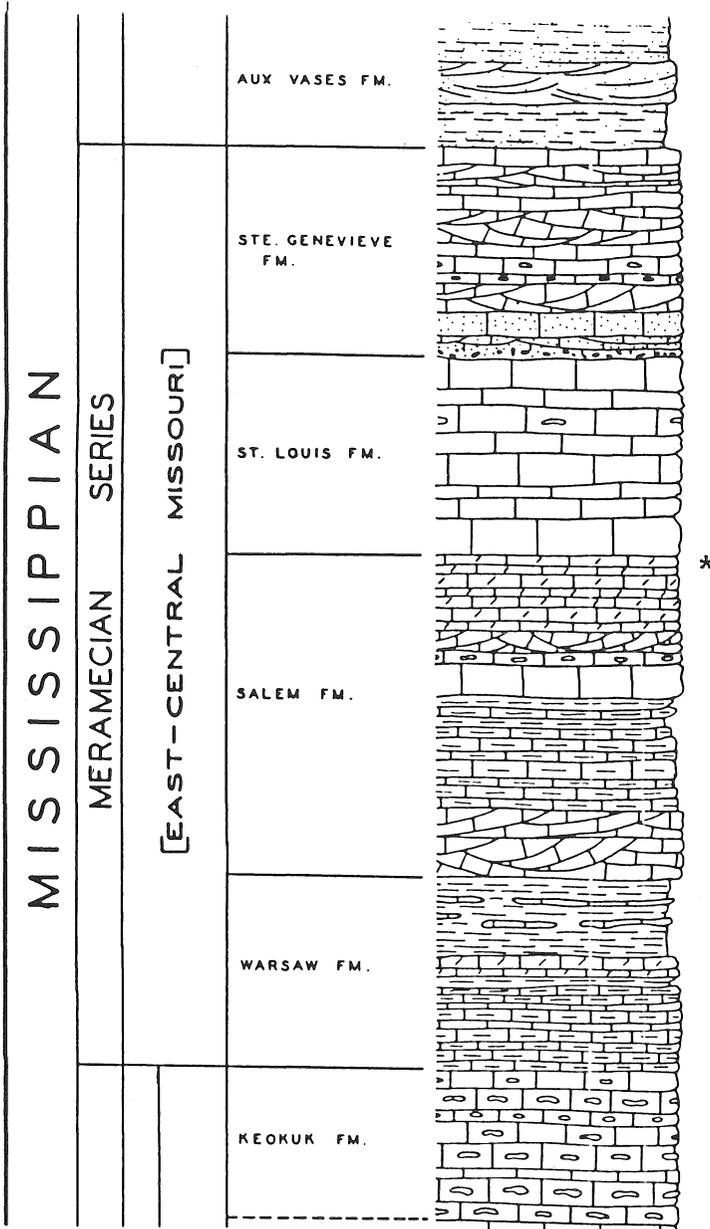


Fig. 2. Columnar section showing collecting horizon (*). (Modified from Howe and Koenig, Plate 1, 1961).

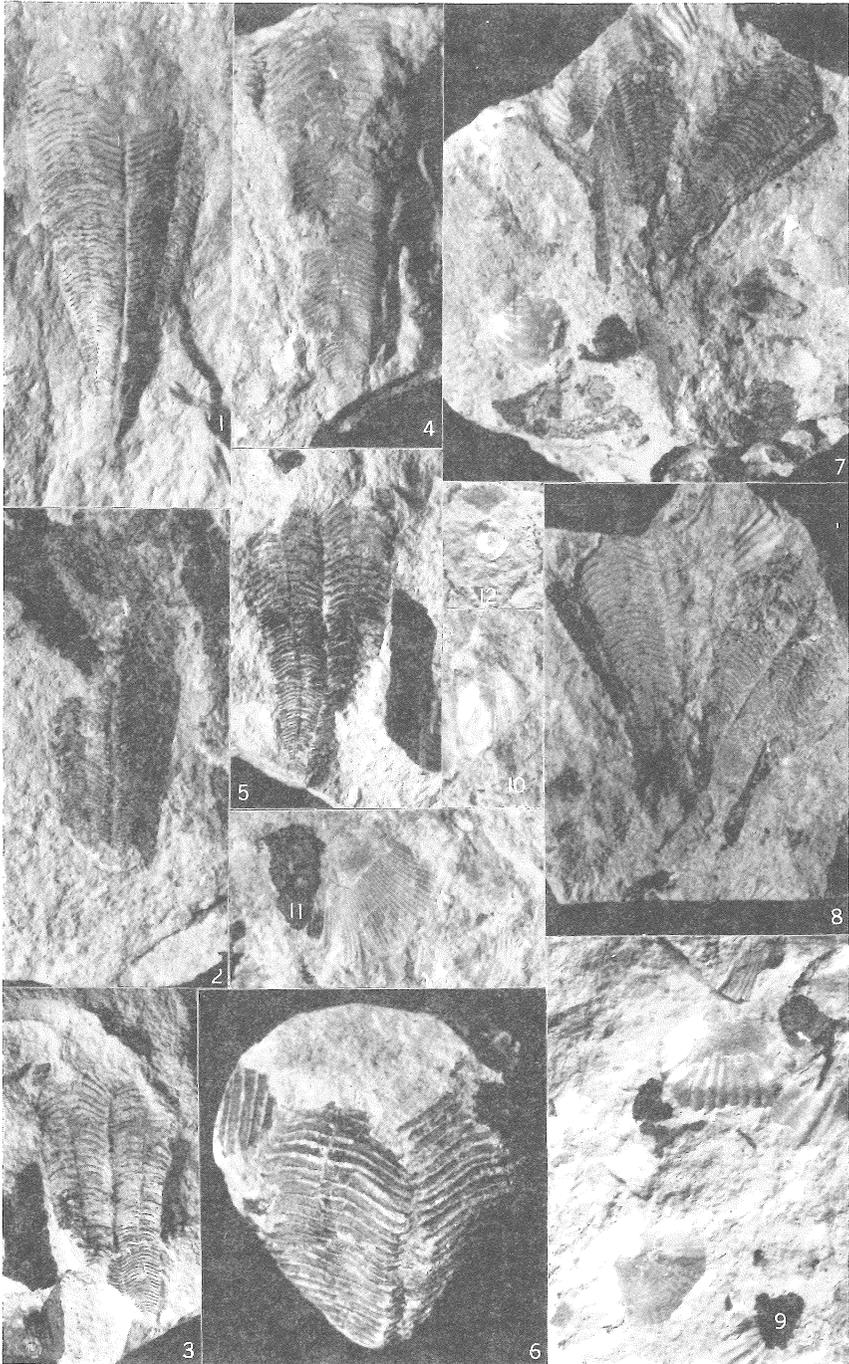


Plate 1

- Fig. 1. *Paraconularia subalata* (Hall). Lateral view of a nearly complete specimen lacking only the apertural area, slightly compressed with original skeletal material. Length 40 mm. S.I.U.M. No. 5601.
- Fig. 2. *P. subalata*. Lateral view showing well-preserved, closely-spaced transverse ridges that curve "downwards" at the sides. Original skeletal material. Length 31.5 mm. S.I.U.M. No. 5604a.
- Fig. 3. *P. subalata*. Lateral view of an external mold showing uninterrupted transverse ridges at midline. Length 27 mm. S.I.U.M. No. 5604b.
- Fig. 4. *P. subalata*. Lateral view of a silicified specimen. Length 45 mm. S.I.U.M. No. 5603.
- Fig. 5. *P. subalata*. Lateral view of a slightly flexed specimen. Original skeletal material. Length 30 mm. S.I.U.M. No. 5604c. Note *Valmeyerodendron* remains.
- Fig. 6. *P. subalata* (?). Oblique view showing the "folded" apertural area of a large compressed specimen. Original skeletal material. Length 30.5 mm. S.I.U.M. No. 5602.
- Fig. 7. *P. subalata*. Specimen on left shows two lateral faces and well-developed corner area. Specimen on the right shows essentially uninterrupted transverse ridges at midline. Length left specimen 31 mm. S.I.U.M. No. 5604d.
- Fig. 8. *P. subalata*. External mold of previous specimen (S.I.U.M. No. 5604d). S.I.U.M. No. 5604e.
- Fig. 9. *Camarotoechia mutata* (Hall). Pedicle view of mature specimen (top) and immature specimen. Length of mature specimen 11 mm. S.I.U.M. No. 5702.
- Fig. 10. *Dictyoclostus* sp. Pedicle view. Length 10 mm. S.I.U.M. No. 5702.
- Fig. 11. *Eumetria verneuiliiana* (Hall). Pedicle view. Length 14 mm. S.I.U.M. No. 5703a.
- Fig. 12. Gastropod sp. indet. Lateral view. Diameter 3.7 mm. S.I.U.M. No. 5703b.

(S.I.U.M. refers to Southern Illinois University Museum)

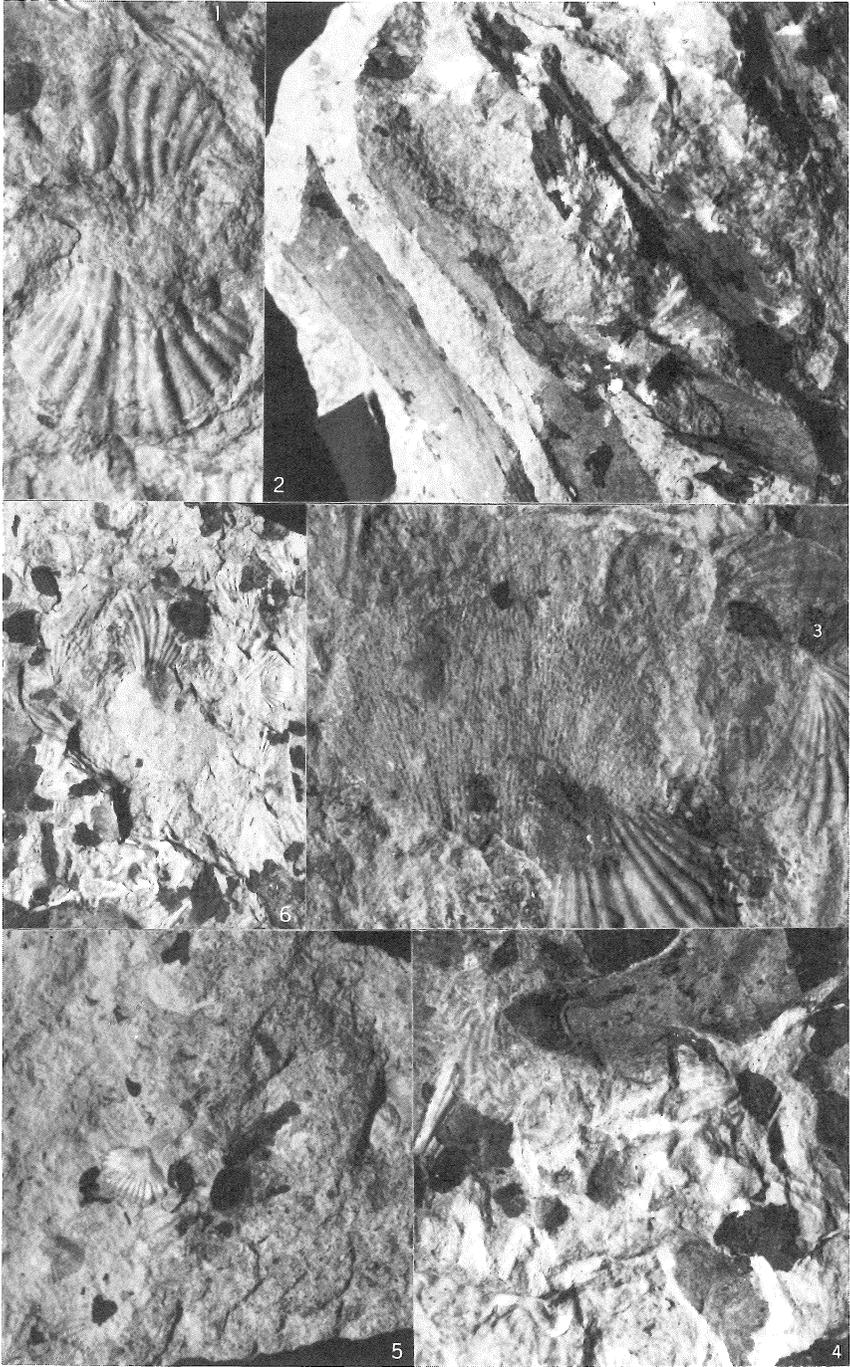


Plate 2

- Fig. 1.** *Spirifer pellaensis* S. Weller. Pedicle view. Width of lower specimen 24.5 mm. S.I.U.M. No. 5705.
- Fig. 2.** Fenestellid bryozoan. Lateral view. Length 31 mm. S.I.U.M. No. 5704.
- Fig. 3.** Ramose bryozoans. Lateral view. Width of field 37.2 mm. S.I.U.M. No. 5704.
- Fig. 4.** *Valmeyerodendron triangularifolium* Jennings. Lateral view. Width of field 104 mm. S.I.U.M. No. P-290.
- Fig. 5.** View of part of a slab showing preservation, attitude, and distribution of *Camarotoechia*. Width of field 83 mm. S.I.U.M. No. 5702.
- Fig. 6.** View of part of a slab showing state of preservation, attitude, and distribution of *Spirifer* and the bryozoans. Width of field 79 mm. S.I.U.M. No. 5704.

These specimens have been identified as *Paraconularia subalata* (Hall) because of their apical angle (about 20°), their ridge spacing (14 in 10 mm. at 10 mm. width), their ridge curvature (away from the aperture at the sides), and their size, which features are comparable to those of *P. subalata* (Hall, 1883 and Cumings, 1905). These specimens exhibit striae on the transverse ridge. *P. subalata*, along with other conulariid species, has been reported previously from the Middle Mississippian at Alton, Illinois (Hall, 1883) and from the St. Louis Limestone (Middle Mississippian) at St. Louis (Keyes, 1894).

Materials and Methods

This work is based on eight specimens of *P. subalata* (Plate 1, Figs. 1-8). Slabs of fossil-bearing limestone as well as the individual specimens of the conulariids were collected in order to document the associated fauna and flora, its condition of preservation, and the relative position of the elements of that fauna and flora on bedding planes.

Discussion and Results

Feldman and Babcock (1986) recently reported an occurrence of exceptionally preserved conulariids from the black shales of the Cuyahoga Formation (Lower Mississippian, Kinderhookian) of northeastern Ohio. Their material consisted of five specimens, some partially decomposed and disarticulated and others nearly complete. The former specimens indicated that the exoskeleton has two components, a multi-layered, flexible integument consisting of interlayered protein, and calcium phosphate which is supported by chitinophosphatic rods. The surface expression of these rods when covered by integument is prominent transverse ridges, which articulate at the corner grooves. This type of exoskeleton is unique to the conulariids and justifies placing them in a distinct phylum. The nearly complete specimens that Feldman and Babcock studied were bent and somewhat compressed (compacted). These facts indicate that the exoskeletons of these conulariids were somewhat flexible, because none of the specimens were torn or broken. Associated with the Cuyahoga conulariids in the black shales are inarticulate brachiopods, fish remains, plant remains, and microfossils such as conodonts, foraminifer, scolecodonts, sponge spicules, and plant spores. These fossils include nektonic or nektobenthonic organisms such as the fish and conodonts and pseudoplanktonic forms such as the conulariids.

The specimens from the Salem limestone also are somewhat bent and compressed (compacted) (Plate 1, Figs. 5 and 1). They are not torn or broken, indicating flexibility of the exoskeleton, and none of the specimens is disarticulated. These specimens of conulariids were found in association with the brachiopods *Camarotoechia mutata* (Hall) (Plate 1, Fig. 9), *Spirifer pellaensis* Weller (Plate 2, Fig. 1), *Dictyoclostus* sp. (Plate 1, Fig. 10), and *Eumetria* sp. (Plate 1, Fig. 11), as well as fenestellid and ramose bryozoans (Plate 2, Figs 3 and 4) and an unidentifiable gastropod (Plate 1, Fig. 12). More importantly, these conulariids and associated marine invertebrates occur with abundant, rather well-preserved remains of the lycopod *Valmeyerodendron triangularifolium* Jennings, a fossil of a nonmarine plant (Plate 2, Fig. 2). *Valmeyerodendron triangularifolium* was

originally reported from the Salem Limestone near Valmeyer, Illinois (Jennings, 1972).

Camarotoechia occurs as randomly distributed, articulated, complete specimens, indicating transport for a short distance (Plate 2, Fig. 5). It was interpreted in the past to be an onshore, marine organism (Bretsky, 1968). *Spirifer*, on the other hand, occurs as disarticulated, randomly distributed, whole valves (mostly pedicle valves) suggesting transport for a considerable distance (Plate 2, Fig. 6). The fenestellid and ramose bryozoans likewise have undergone transport for a considerable distance, as evidenced by their occurrence as localized broken parts of colonies (Plate 2, Fig. 6). *Spirifer* has been interpreted as a shallow marine, shelf-dwelling organism (Bretsky, 1968). *Paraconularia* is present as nearly complete, articulated but slightly compressed and bent specimens, some of which are external molds (Plate 1, Figs. 3 and 8), others of which have been replaced by silica (Plate 1, Fig. 4), but most of which are preserved as original exoskeletal material (Plate 1, Figs. 1, 3, 5-7). Considering the nature of the conulariid exoskeleton, they probably were not transported for any great distance. The specimens of *Valmeyerodendron* being rather well-preserved also were probably not transported far. But, being land plant remains, they were moved seaward, while *Spirifer* and the bryozoans were carried shoreward.

Conclusions

The available evidence indicates that the Salem formation specimens of *Paraconularia subalata* lived in an onshore environment. This evidence reaffirms the interpretation that at least some conulariids were onshore organisms as had been held for several decades. However, it is unusual to find an abundance of conulariids in a fine-grained limestone, and even more unusual to find them in association with abundant well-preserved remains of the terrestrial lycopod, *Valmeyerodendron triangularifolium*.

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Chromium in a Sandy Soil Contaminated by Aluminum Etching Waste Fluids

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Abstract: An aluminum window manufacturing plant in Malden, Missouri contaminated a sandy soil with blue-green Cr-Al coprecipitates from effluent suspensions. A bimodal Cr distribution with peak concentrations at the surface and at approximately 1 m demonstrates Cr mobility in this soil. Elevated Cr at 1 m is associated with increased clay content and Mn(II). Chromium's mobility is attributed to a rapid leaching of chromate at the time of deposition and the possible very slow dissolution of $\text{Cr}(\text{OH})_4^-$. Significant amounts of chromate were likely reduced to Cr(III) oxyhydroxides because of organic matter oxidation and hydrolysis.

Introduction

Stable chromium (Cr) oxidation states in soil environments are limited to chromic (3+) and chromate (6+) species (Baes and Mesmer 1976). Bartlett and Kimble (1976a,b), Bartlett and James (1979) and James and Bartlett (1983a,b,c) demonstrated that chromic hydrolysis is a dominant soil process. They observed that chromate is partially extractable by a buffered phosphate solution, which they termed "exchangeable Cr". In acidic soil environments enriched with organic matter chromate may be reduced to chromic species. Evidence collected by Bartlett and James (1979) demonstrated that Cr(III) was easily oxidized with Mn oxides being the electron acceptors.

Sposito (1981) theoretically evaluated the chromic - Mn oxide redox couple and concluded that acidic soil environments containing Mn-oxides and permitting chromate removal should be capable of inducing chromic oxidation. In contrast, Grove and Ellis (1980a,b) suggested that reduction alone accounted for the disappearance of soluble Cr(VI) added to three soils, but they did not try to measure Cr(III) that might have been formed. They postulated that the observed Mn reductions were the result of organic matter oxidation induced by low pH resulting from Cr(III) hydrolysis. Stollenwerk and Grove (1985) demonstrated that Fe oxyhydroxide coatings were principally responsible for Cr(VI) sorption. Chromic hydrolysis and co-precipitation into Fe-oxides was proposed to follow Cr(VI) reduction. Baes and Mesmer (1976) reviewed evidence that $\text{Cr}(\text{OH})_4^-$ is formed from Cr hydroxides in alkaline media. Bartlett and Kimble (1976b) demonstrated that chromium is coprecipitated with Al at pH 6 and significantly increased its solubility above pH 8.

The objectives of this investigation were to determine the Cr depth distribution in a sandy Cr contaminated soil by means of selective extractions and to propose a mechanism to explain chromium mobility.

Site Description

A small abandoned aluminum-window manufacturing plant at Malden, Missouri, contaminated portions of an industrial park by discharging spent chromium-containing etching fluids. The affected soil is of the Malden series (mixed, thermic Typic Udipsamments) typically exhibiting a deep, well drained loamy sand profile with an A-B-C horizon sequence. Contaminated soil resides behind the plant and is bounded by slightly elevated areas which were spared fluid inundation. Grossly contaminated areas are devoid of vegetation and exhibit blue-green granular aggregates having a firm consistence. Bermudagrass (*Cynodon dactylon* (L.) Pers.) forms a dense sod on adjacent areas.

Freshly prepared etching fluids usually contain mixtures of dichromate and sulfuric acid. These fluids are used to etch aluminum metal until their oxidizing potential is spent. Normally, spent solutions are treated with a base to neutralize the sulfuric acid and to coprecipitate Al and Cr, which are then separated from the mother liquor by sedimentation and transferred to a reprocessing plant. Unfortunately, at the Malden site these fluids and coprecipitates were repeatedly discharged for several years onto adjacent soil.

Methods

Three soil pits were excavated for detailed profile characterization according to Soil Survey Staff (1984). Sampling was performed in maximum 10 cm increments with exact sample boundaries based upon observed textural and structural boundaries. All samples were air dried, with subsamples oven-dried at 110°C for 24 hrs.

Soil suspensions for pH measurement were prepared by mixing equal volumes of air-dried soil and water. Exchangeable Ca, Mg, K, Cr and Mn were extracted with buffered ammonium acetate and exchangeable aluminum was extracted with *N* KCl. Aluminum was analyzed colorimetricly (Hsu 1965) with all other elements analyzed by flame atomic absorption spectroscopy (FAA). Particle size distribution was determined by the Bouyous hydrometer method. Each of these methods was duplicated and is referenced in Black *et al.* (1965).

Total chromium was defined as chromium dissolved by reagent grade nitric acid. Two grams of oven-dried soil was digested with 2 mL of conc HNO₃ for 30 minutes in a boiling water bath. Digests were diluted with water, then centrifuged with the decantate saved. This procedure was repeated three additional times before samples were washed with *N* NaCl. The combined decantates were analyzed for Al, Cr, Mn, and Fe by FAA. Chromate was extracted with a potassium phosphate buffer and determined colorimetrically with *s*-diphenyl carbazide (Bartlett and Kimble, 1976a; James and Bartlett, 1983b). Metal fractionation was determined by selective sequential extraction according to Shuman (1985).

To estimate the chromate dissolution potential, a series of suspensions representing each depth increment was prepared. Water, 0.001M EDTA

(ethylenediamine tetracetic acid), 0.001M sodium carbonate and a 0.001M acetic acid - sodium acetate buffer were individually added to air-dried samples to provide suspensions with equal amounts of soil and solution. Suspensions were equilibrated in capped plastic vials for 10 days, centrifuged, and analyzed for chromate by the s-diphenyl carbazide method.

Results

To avoid unnecessary duplication of information from the three soil sites, only the data from the most contaminated site will be addressed. The profile description (Table I) shows it to be typical of the Malden series, except for a series of clayey layers at approximately 1 m. This site exhibits a neutral to slightly alkaline reaction, a sandy loam texture with weak fine blocky structures at 32-47 cm and a series of horizons at 55-142 cm which are more clayey than typical. A few fine distinct yellow (10YR 7%) mottles occur at 112-142 cm and many fine to medium Fe and Mn masses occur at 55-142 cm. At 183 cm a water table was encountered.

Exchangeable Ca, Mg, and K increase proportionally to the clay content. Ammonium acetate exchangeable Cr is present at 0-16 and again at 142-183 cm. Exchangeable Mn is present in the upper 91 cm, especially between 47-91 cm.

The upper 8 cm contains approximately 5860 mg Cr/kg-soil, decreasing to approximately 510 mg Cr/kg-soil at 8-16 cm (Table I). Cr continues to decline with increasing depth until 47-55 cm; thereafter, > 50 mg Cr/kg-soil exists until 91 cm. Horizons deeper than 91 cm exhibit a lower, relatively constant Cr

Table I. Selected physical and chemical properties

Depth cm	pH	Sand %	Clay %	N NH ₄ OA _c		exchangeable cations			Total Cr ppm	P-exchangeable Cr ppm
				Ca	Mg	K	Cr	Mn		
0-8	7.7	76	7	0.31	0.34	0.61	0.09	0.004	5860	11
8-16	8.4	86	8	0.15	0.07	0.34	0.05	0.02	510	5
16-24	8.4	82	10	0.24	0.06	0.35	0	0.03	310	5
24-32	8.1	85	8	0.10	0.10	0.27	0	0.04	400	0
32-39	7.6	79	11	0.08	0.13	0.17	0	0.03	25	0
39-47	7.7	75	14	0.08	0.13	0.17	0	0.02	5	0
47-55	8.2	61	23	0.54	0.38	0.23	0	0.04	25	0
55-57	8.1	65	20	0.60	0.38	0.28	0	0.05	50	5
57-70	8.6	38	34	5.21	2.66	0.71	0	0.05	110	7
70-80	8.0	13	67	10.31	4.79	0.74	0	0.09	50	7
80-91	7.6	11	65	9.11	5.41	0.70	0	0.09	100	5
91-112	7.5	17	43	11.03	7.33	0.78	0	0	20	5
117-135	7.5	15	37	13.08	5.83	0.58	0	0	25	5
135-142	7.6	24	32	6.16	4.91	0.41	0	0	30	0
142-161	7.4	82	13	1.50	0.05	0.11	0	0	25	0
161-183	6.8	91	8	0.57	0.04	0.03	0	0	10	0

distribution. The buffered phosphate extraction displaced chromate at 0-24 cm and at 55-135 cm with this second region associated with increased clay contents.

Selective extraction of Cr, Mn, and Fe (Table II) indicates that only Mn is significantly associated with exchangeable, organic and Mn-oxide fractions. The surface horizon did show minor Cr concentrations in these three chemically defined environments, but Cr is mainly associated with the noncrystalline and crystalline iron oxide environments with the former exhibiting somewhat higher concentrations. Iron and Mn are expressed in the noncrystalline fractions to a large extent. The contaminated surface was the only sample to release more than trace levels of chromate into the various equilibrating media. Chromate solubility increased in the following order: EDTA (0.06 mg/kg, pH=6.9) < sodium carbonate (0.12 mg/kg, pH=7.9) < acetic acid buffer (0.18 mg/kg, pH=5.1) < water (0.85 mg/kg, pH=8.2).

Table II. Selective extraction of chromium, manganese and iron

Depth cm	Exchangeable	Organic	Mn-oxides % of total metal	Noncrystalline	Crystalline	Total ppm
				Fe	Fe	
<i>Cr</i>						
0-8	0.4	2	0.8	48	47	3860
8-16	1.1	0	0	81	17	710
16-24	0	0	0	80	20	325
24-32	0	0	0	89	11	225
32-39	0	0	0	75	25	60
55-57	0	0	0	75	25	60
70-80	0	0	0	75	25	60
135-142	0	0	0	0	100	15
<i>Mn</i>						
0-8	0.5	13	4	35	47	180
8-16	1.0	44	8	40	6	470
10-24	0.8	42	8	36	12	1020
24-32	1.3	23	6	58	11	925
32-39	0.5	10	2	58	28	1420
55-57	0.9	13	3	59	23	1470
70-80	2.9	24	24	16	32	840
135-142	0	66	0	29	5	300
<i>Fe</i>						
0-8	0	0	0	18	81	2150
8-16	0	0	0	27	72	4750
16-24	0	0	0	34	66	5875
24-32	0	0	0	46	54	5150
32-39	0	0	0	47	53	5875
55-57	0	0	0	59	41	8450
70-80	0	0	0	25	75	12000
135-142	0	0	0	48	51	7475

Discussion

When base-neutralized Cr suspensions were repeatedly spread onto the site, Cr was essentially composed of Cr(III) oxyhydroxides and residual amounts of Cr(VI). Chromic oxyhydroxide aggregates (formed by hydrolysis during the base neutralization process in the factory) are largely retained at the soil surface. Chromate, being more mobile, likely infiltrated deep into the soil, being partially adsorbed by Fe oxides associated with clayey horizons. Phosphate extractable Cr appears to show maximum concentration at depths dominated by clay and its associated iron oxides, suggesting chromate adsorption.

Total Cr shows a secondary maximum associated with the clayey layers. Phosphate extractable Cr accounts for approximately 5 to 10% of the total Cr. Bartlett and Kimble (1976b) stated that the phosphate extraction was specific for Cr(VI), but was not exhaustive. Therefore, the majority of the nonphosphate extractable Cr may be Cr(VI).

In the upper 91 cm, exchangeable Mn is relatively abundant. It is tempting to state that Mn(II) is a product of Cr oxidation; however, given the mottling patterns, Mn(II) may be caused by anaerobic conditions within the gleyed, clayey horizons. A more likely scenario involves a relatively rapid infiltration of the residual concentrations of Cr(VI) followed by a slow Cr induced oxidation of organic materials. Chromic hydrolysis could easily account for the Mn(II). Such a model was proposed for a different series of soils by Grove and Ellis (1980a).

Organic matter oxidation by residual amounts of chromate species would be expected to eventually produce a stable soil situation where Cr migration would cease because of the limited supply of Cr(VI) and the perceived immobility of Cr(III). However, when the Cr aggregates were equilibrated in water the Cr solubility was substantial. Baes and Mesmer (1976) observed that $\text{Cr}(\text{OH})_4^-$ was quite soluble in alkaline media. The pH of the water plus Cr-containing aggregates was >8.0 . Given the solubility and the soils alkaline reaction, it is possible that slowly released $\text{Cr}(\text{OH})_4^-$ may contribute to the downward migration of Cr.

Acknowledgement

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Pulse Response of a Fabry-Perot Interferometer

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Abstract: In both advanced undergraduate laboratories and graduate research the Fabry-Perot interferometer and etalon have found applications in analyzing the output of pulsed lasers or in the spectral analysis of the radiation emitted from a pulsed laser excited experiment. When pulsed laser systems are used, whether single pulsed or as a train of pulses from a mode-locked laser, a finite number of beams interfere, as in the case of the Lummer Gekrike plate. Operation of the interferometer with single pulses and pulse trains are considered.

Introduction

In both the research laboratory and the advanced undergraduate laboratory pulsed lasers and the Fabry-Perot (FP) interferometer or etalon are used to perform spectral analysis on laser output. A pulsed laser may be used to excite or induce a reaction in another medium and the radiation output from this medium is also pulsed and may be spectrally analyzed with the interferometer. In both cases the response of the interferometer will depend on the pulse length of a single pulse or on the number of pulses in the pulse train and on the pulse separation and pulse width.

Single-pulsed lasers are lasers which are manually pulsed and emit one short-duration pulse, or lasers which have a low pulse repetition rate and each pulse itself is very narrow. A pulsed train means a train of pulses emitted from, for example, a mode-locked laser which may have different pulse widths, pulse separation, and total number of pulses in the train. The pulsed response of the FP has been treated in the literature by Roychoudhuri,¹ but most undergraduate students are probably unaware of this paper and with the increased use of lasers and the FP interferometer and etalon in the laboratory this discussion deserves repeating.

A FP may be used in two modes. When it is normally irradiated by a well-collimated beam of wavelength λ_0 , it is in the filter mode. This is the typical method for laser irradiation. A lens focusses the beam from the FP on a screen and, depending on the wavelength and mirror spacing, a central fringe of highest order and concentric fringes of lower order are formed on the screen. The time delay between adjacent interfering rays is $\tau_0 = \frac{2nd}{c}$, where n is the index of refraction of the medium between the plates.

When the usual light source is used or light is emitted from an experimental region irradiated by a laser, the light source is extended. Rays enter at various angles θ , and for light of wavelength λ_0 only rays traveling at a definite angle θ_m produce the m th order interference fringe on the screen when focussed by a lens. For each wavelength in the source a set of fringes of equal inclination are formed, and this is called the fringe mode.

The sharpness of the interference lines is described by the term finesse in the optical region. In the millimeter, microwave, and radio-frequency regions the sharpness is defined by the term quality-factor, Q .

Brief Review of Infinite Beam Interference²⁻⁴

A sketch of the FP operating in both the filter and fringe modes is seen in Figure 1. It will be assumed in the discussion that there is air between the mirrored surfaces. The internal and external reflection coefficients are r and r' where $r = -r'$. The transmission coefficients into and out of the cavity are t and t' . Figure 2 is the intensity pattern of the cavity with high and medium reflectance

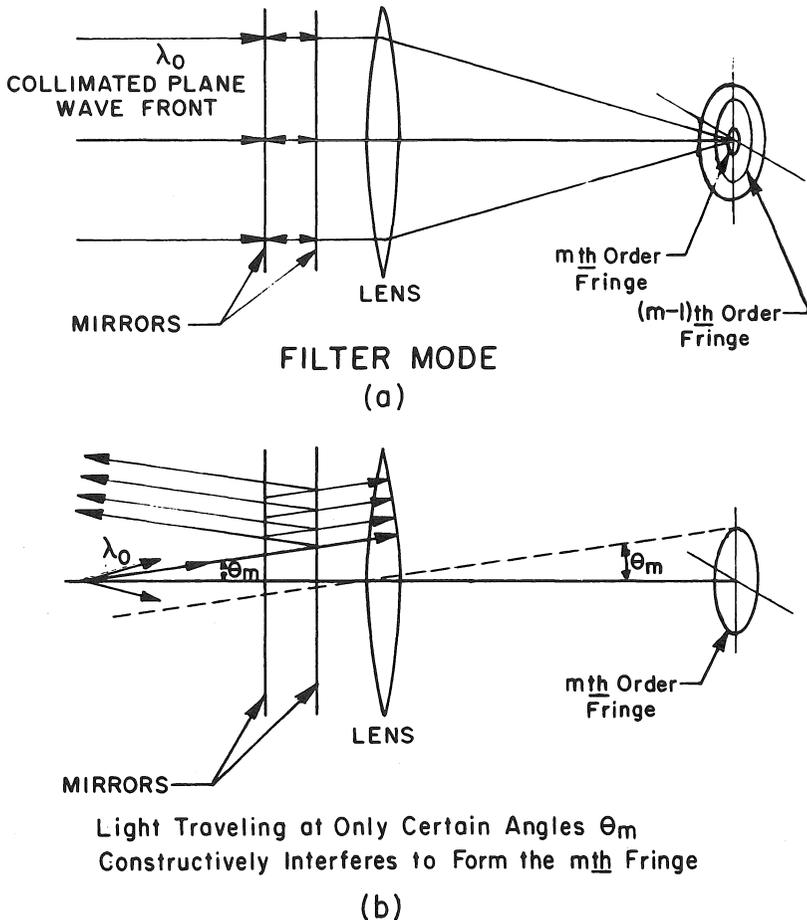


Fig. 1. A sketch of the interferometer operated in the filter and fringe mode

- (a) filter mode
(b) fringe mode.

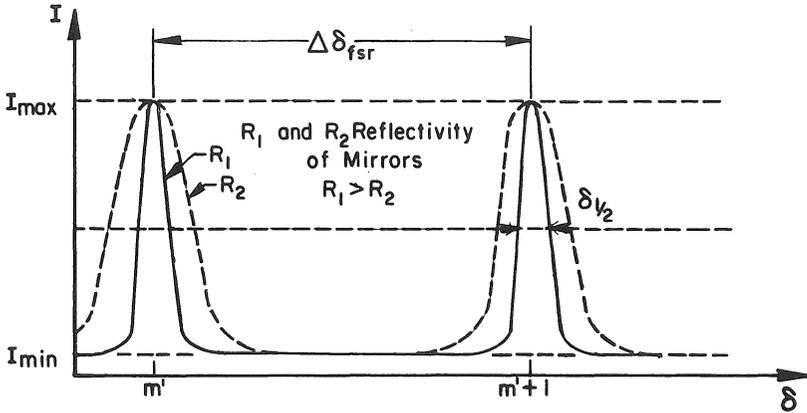


Fig. 2. A sketch of the intensity pattern for an FP with two mirror reflectances.

versus the phase angle. Two orders of interference are shown and this is called the asymptotic Airy function, where the number of interfering beams approach infinity. Both mirrors are assumed to be identical with reflectance $R=r^2$ and assuming the medium between the plate and medium in which it is immersed are identical, the transmittance is $T = tt'$.

The incident monochromatic ray is of wavelength λ_0 and is incident at an angle θ to the normal to the FP. A perfect monochromatic wave has an infinite temporal extent and the transmitted field is

$$A^t = A^i [tt' + tt'r^2e^{i\delta} + tt'r^4e^{2i\delta} + \dots + tt'r^{2(n-1)}e^{(n-1)i\delta}] \tag{1}$$

in which δ is the round trip phase difference $\delta = 4\pi d \cos\theta/\lambda_0 + 2\phi$, where ϕ is any phase change on reflection.

With high reflectance of the mirrors, n approaches infinity and Equation (1) becomes

$$\begin{aligned} A^t &= A^i T [1 + Re^{i\delta} + R^2e^{2i\delta} + \dots + R^{(n-1)}e^{(n-1)i\delta} + \dots] \\ &= A^i T \sum_{n=0}^{\infty} R^n e^{ni\delta} = A^i T / (1 - Re^{i\delta}) \end{aligned} \tag{2}$$

The transmitted intensity

$$I^t = I^i T^2 / \left\{ 1 + R^2 - 2R \cos \delta \right\} = I^i T^2 / \left\{ (1 - R)^2 + 4R \sin^2 (\delta/2) \right\} \tag{3}$$

If all losses are neglected, $I^i = I^r + I^t$ or $I^r/I^i + I^t/I^i = 1$, but the reflectance by definition is $R = I^r/I^i$ and the transmittance in our case is $T = I^t/I^i$, so $T = 1 - R$. Then

$$I^t = I^i / \left\{ 1 + 4R \sin^2 (\delta/2) / (1 - R)^2 \right\} = I^i / \left\{ 1 + F \sin^2 (\delta/2) \right\} \tag{4}$$

in which F is called the finesse coefficient

$$F = 4R / [1 - R]^2 \tag{5}$$

and the Airy function representing the ratio I^t/I^i is

$$\mathcal{A}(\delta) = [1 + F \text{Sin}^2(\delta/2)]^{-1}. \tag{6}$$

The Airy functions for various R are seen in Figure 2.

For a lossless ideal FP the intensity pattern is represented by the Airy function. Neglecting reflection phase shifts, the intensity maximum in the mth order occurs at $\delta = 2m\pi$ where m is an integer and the half intensity point occurs at $\delta = 2m\pi \pm \Delta\delta_{1/2}/2$. For the lossless interferometer

$$I^t/I^i = 1/2 = 1 / \left\{ 1 + F \text{Sin}^2 \left[\left(2m\pi \pm \Delta\delta_{1/2}/2 \right) / 2 \right] \right\} = 1 / \left[1 + F \text{Sin}^2 \left(\Delta\delta_{1/2}/4 \right) \right].$$

Now $\Delta\delta_{1/2}$ is small, then

$$\begin{aligned} 1 + F \left(\Delta\delta_{1/2} \right)^2 / 16 &= 2 \\ \Delta\delta_{1/2} &= 4\sqrt{F}. \end{aligned} \tag{7}$$

The only loss assumed is the transmission by the mirrors and the ideal reflectivity finesse is

$$\mathcal{F}_R = \pi \sqrt{F}/2 = \pi \sqrt{R}/(1-R). \tag{8}$$

In discussing the resolving power of a grating, the Rayleigh criterion of resolution is used. In the single slit two close lying lines of wavelength λ_0 and $\lambda_0 + \Delta\lambda$ are resolved when the maximum intensity of λ_0 occurs at the intensity minimum of the line at wavelength $\lambda_0 + \Delta\lambda$. Both lines are assumed to have equal intensity and the intensity contour is given by the function $I = I_{\max} (\sin u/u)^2$ and the lines are shown in Figure 3. Assume maximum at λ_0 occurs when $m=0$, so $u=0$ and the minimum occurs at $u = \pi$. The combined contour of both of the lines has a saddle point minimum at $u = \pi/2$. Then

$$I_{sp} = 2I_{\max} \sin^2(\pi/2) / \pi^2 = 4 \left(8/\pi^2 \right) I_{\max} = .811 I_{\max}. \tag{9}$$

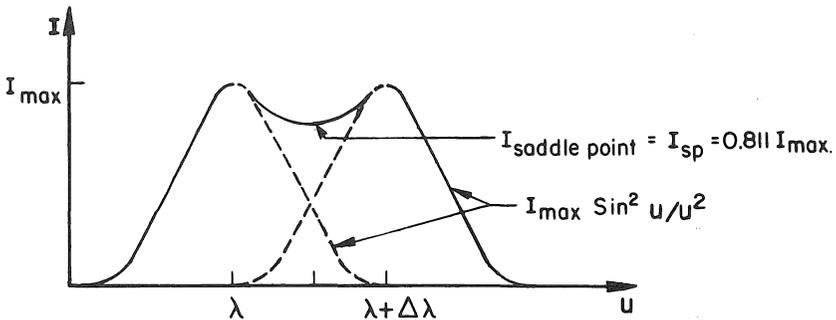


Fig. 3. Sketch demonstrating the Rayleigh criterion for a slit.

For the FP in the m th order, neglecting reflection, maxima intensity occurs at phase angles δ and $\delta + \epsilon$ for the line of wavelength λ_0 and $\lambda_0 + \Delta\lambda$ and the saddle point is at phase angle $\delta + \epsilon/2$ for the λ_0 line and $\delta - \epsilon/2$ for the $\lambda_0 + \Delta\lambda$ line. Then the intensity at the saddle point for the m th order, $\delta = 2m\pi$, is

$$I_{sp}^{\downarrow} = I^{\downarrow} \left\{ 1 / \left[1 + F \sin^2 \left[\left(2m\pi + \epsilon/2 \right) / 2 \right] \right] + 1 / \left[1 + F \sin^2 \left[\left(2m\pi - \epsilon/2 \right) / 2 \right] \right] \right\} = 2I^{\downarrow} / \left[1 + F \sin^2 \left(\epsilon/4 \right) \right]. \tag{10}$$

From Figure 2 the intensity of $\lambda_0 + \Delta\lambda$ and λ_0 when separated by $\Delta\delta = \epsilon$ is

$$I_{max}^{\uparrow} = I^{\uparrow} \left(2m\pi + \epsilon \right) + I^{\uparrow} \left(2m\pi \right) = I^{\uparrow} \left\{ 1 + 1 / \left[1 + F \sin^2 \left(m\pi + (\epsilon/2) \right) \right] \right\} = I^{\uparrow} \left\{ 1 + 1 / \left[1 + F \sin^2 \left(\epsilon/2 \right) \right] \right\}. \tag{11}$$

Then

$$I_{sp} = .811 I^{\uparrow} \left\{ 1 + 1 / \left[1 + F \sin^2 \left(\epsilon/2 \right) \right] \right\} = 2I^{\uparrow} / \left[1 + F \sin^2 \left(\epsilon/4 \right) \right].$$

Since ϵ is small, then

$$F^2 \epsilon^4 - 15.5 F \epsilon^2 - 30 = 0$$

$$\epsilon = 4.5 / \sqrt{F} = 2.07 \pi / \mathfrak{F}_R. \tag{12}$$

For the m th order maximum

$$\delta = 2m'\pi = 4\pi d \cos \theta / \lambda_0 \text{ so } \Delta\delta = \epsilon = -4\pi d \cos \theta \Delta \lambda / \lambda_0^2$$

in which the true phase charge on a round trip is $\delta = 2m\pi = 4\pi d \cos \theta / \lambda_0 + 2\phi$

where ϕ is the reflection phase charge at the mirrors, so $2m'\pi = 4\pi d \cos \theta / \lambda_0$ and $m' = m + e$. Then

$$\epsilon = -2m'\pi \Delta \lambda / \lambda_0, \text{ and}$$

$$R = \lambda_0 / \Delta\lambda = 2m'\pi / \epsilon = 0.97 \mathfrak{F}_{Rm'}. \tag{13}$$

From the analogy of the diffraction grating the effective number of beams is

$$N' = 0.97 \mathfrak{F}_R \tag{14}$$

and in this limit the Airy function is closely approximated.

Finite Number of Beams²

As has been indicated, when a single laser pulse or a train of short pulses from a mode-locked laser are analyzed, one may have a finite number of terms in the sum in Equation (1).² Then Equation (2) has the form

$$A_p^{\uparrow} = A^{\uparrow} T \sum_{n=1}^{p-1} R^n e^{nj\delta} = A^{\uparrow} T \left(1 - R^p e^{pj\delta} \right) / \left(1 - R e^{j\delta} \right) \tag{15}$$

in which $R = rr' = -r^2$ and $T = tt'$ assuming $\theta \simeq 0$.

The intensity is

$$I_p^t = I^t T^2 \left[\frac{1 + R^{2p} - 2R^p \cos(p\delta)}{1 + R^2 - 2R \cos \delta} \right] \\ = I^t T^2 \left[\frac{(1 - R^p)^2 + 4R^p \sin^2(p\delta/2)}{(1 - R)^2 + 4R \sin^2(\delta/2)} \right] \quad (16)$$

in which $I_p^t = A^t A^{t*}$ and $I^t = A^i A^{i*}$.

Now let

$$T_p = T^2 (1 - R^p)^2 / (1 - R)^2 < T, \quad (17)$$

$$F_p = 4R^p / (1 - R^p)^2 < F, \quad (18)$$

$$\text{and } F = 4R / (1 - R)^2 \quad (19)$$

so

$$I_p^t = I^t T_p \left[\frac{1 + F_p \sin^2(p\delta/2)}{1 + F \sin^2(\delta/2)} \right] \quad (20)$$

This is exactly the form of the interference pattern of the Lummer Gekrike² plate where the light is incident at a large angle θ so only a finite number of beams are possible before walk-off.

If I_p^t is plotted vs. the phase angle δ for a finite number of beams, the interference pattern is wider than for the usual asymptotic solution assuming $n \gg \infty$ and it has a series of weak secondary maxima between the principal maxima. Neglecting the phase change on reflection from the mirrors, the curve has a principal maximum in the m th order at $\delta = 2m\pi$ and it has minima when $\delta = (2m + n/p)\pi$, where $n = 1, 2, \dots, p$. The main fringes are broadened and there are secondary maxima depending on the value of p . These secondary maxima decrease rapidly in amplitude. In the m th order the principal maximum occurs at $\delta = 2m\pi$ and equals

$$I_{p_{\max}}^t = I^t T_p = I^t T^2 (1 - R^p)^2 / (1 - R)^2 \quad (21)$$

and if R is close to unity and an absorbance A is assumed, then $T + A = 1 - R$ or write $T + A = X$ and X is small, so

$$\left[1 - (1 - X)^p \right]^2 / \left[1 - 1 - X \right]^2 = \left[1 - 1 + pX \right]^2 / X^2 = p^2$$

so

$$I_{p_{\max}}^t = I^t p^2 T^2 \quad (22)$$

The secondary maxima and minima are

$$I_{p_{\max}}^t = I^t T_p (1 + F_p) / \left[1 + F \sin^2(n\pi/2p) \right] \quad (n \text{ odd}) \quad (23)$$

and

$$I_{p_{\min}}^t = I^t T_p \left[1 + F \sin^2(n\pi/2p) \right] \quad (n \text{ even})$$

The denominator increases from 1 to $1 + F$ as n varies from 0 to p .

The finesse of the FP is defined as the ratio of the free spectral range of the FP to the phase angle for half maximum of the line. The free spectral range is the

distance between fringes at wavelength λ in different orders and corresponds to a phase of 2π . Then

$$\mathfrak{F} = \Delta\delta_{\text{fsr}} / \Delta\delta_{1/2} = \Delta\nu_{\text{fsr}} / \Delta\nu_{1/2} = \Delta\omega_{\text{fsr}} / \Delta\omega_{1/2} = \Delta\lambda_{\text{fsr}} / \Delta\lambda_{1/2}$$

The finesse is a measure of the sharpness of the interference fringes.

In order to determine the finesse of the system when one has a finite number of beams, it is necessary to find the phase angle at half width of the principal maximum in the m th order. Assume that R approaches unity so F approaches infinity, then from Equations (4) and (7)

$$I_{\text{Pmax}}^t = I^t T_p \text{ and } I_{\text{Pmin}}^t \longrightarrow 0 \tag{24}$$

so

$$I_p^t / I_{\text{Pmax}}^t = 1/2 = \left\{ 1 + F_p \text{Sin}^2 \left\{ \left[2mp\pi \pm (p\Delta\delta_{1/2}/2) \right] / 2 \right\} \right. \\ \left. \div \left\{ 1 + F \text{Sin}^2 \left\{ \left[2m\pi \pm (\Delta\delta_{1/2}/2) \right] / 2 \right\} \right\} \right\} .$$

This reduces to

$$\text{Sin}^2 \left[\left(p \Delta\delta_{1/2} \right) / 4 \right] - F \text{Sin}^2 \left(\Delta\delta_{1/2} / 4 \right) / 2 F_p + 1 / 2 F_p = 0 \tag{25}$$

Now $\Delta\delta_{1/2}$ is small so $\text{Sin}^2 \left(\Delta\delta_{1/2} / 4 \right) \simeq \Delta\delta_{1/2}^2 / 16$

and

$$F/F_p = \left\{ 4R \left(1 - R^p \right)^2 \right\} / \left\{ 4R^p \left(1 - R \right)^2 \right\} = \left(1 - R^p \right)^2 / \left\{ R^{p-1} \left(1 - R \right)^2 \right\} \tag{26}$$

and for R approaching unity then $1 - R = T + A = X$ and X is so small so

$$\left(1 - R^p \right) = \left[1 - \left(1 - X \right)^p \right] = 1 - 1 + pX \dots \simeq pX$$

so

$$F/F_p = p^2 X^2 / \left\{ X^2 \left(1 - X \right)^{p-1} \right\} = p^2 / \left(1 - X \right)^{p-1} \simeq p^2 \tag{27}$$

Also

$$\left(1/2 F_p \right) = \left(1 - R^p \right)^2 / 8R^p \simeq p^2 X^2 / 8 \left(1 - X \right)^p \simeq p^2 X^2 / 8 \left(1 + pX + \dots \right) \simeq 0, \tag{28}$$

since X is small.

Equation (25) reduces to

$$\text{Sin}^2 \left(p \Delta\delta_{1/2} / 4 \right) = \left(p \Delta\delta_{1/2} / 4 \right)^2 / 2$$

or

$$\text{Sin} \left(p \Delta\delta_{1/2} / 4 \right) / \left(p \Delta\delta_{1/2} / 4 \right) = \text{Sinc} \left(p \Delta\delta_{1/2} / 4 \right) = 1/\sqrt{2} \tag{29}$$

Then

$$p \Delta\delta_{1/2} / 4 = 0.45 \pi \tag{30}$$

or

$$\Delta\delta_{1/2} = 1.8 \pi / p \tag{31}$$

The reflectivity finesse is

$$\mathfrak{F}_R = \Delta\delta_{\text{fsr}} / \Delta\delta_{1/2} = 2 \pi p / 1.8 \pi = 1.1 p \tag{32}$$

This indicates that the reflectivity finesse is virtually proportional to the number of interfering beams.

Pulse Response¹

As indicated, the FP operation will be analyzed for a single laser pulse and also for a train of very narrow pulses which might occur in the output of a mode-locked laser. These are coherent pulses. The pulses will be assumed to be rectangular, of width δt , and for a train the time separation between pulses is Δt . In this discussion it will be assumed that the FP operates in the filter mode. The laser beam is collimated and incident normally on the FP and the emission wavelength is λ_0 . The time delay of the FP is $\tau_0 = 2d/c$ where d is the plate separation. The pulse width for the single pulse or the pulse separation for the train will be assumed to be an integer multiple of τ_0 . Experimentally this condition may be impossible to fulfill but the FP may be tilted in the laser beam so δt or Δt are integer multiples of $\tau_d = \tau_0 \cos \theta$.

Single Pulse Response

Consider a collimated pulse of wavelength λ_0 normally incident upon the FP and the pulse is an integer multiple of τ_0 or τ_d so

$$\delta t = p \tau_0 \text{ or } p \tau_d \quad (33)$$

As the pulse width and frequency band width are Fourier transforms of each other, then

$$\delta \nu = 1/\delta t$$

This means that the pulse can only be observed if the FP frequency free spectral range is greater than $\delta \nu$ or

$$\Delta \nu_{fsr} > \delta \nu \quad (34)$$

If the incident pulse has a width $p\tau_0$, then within the FP there is the initially transmitted pulse and $(p - 1)$ reflected pulses of decreasing amplitude, which contribute to the intensity maximum. After time $p\tau_0$ the intensity will decrease for all reflected pulses have amplitudes less than the first transmitted pulses. Figures 4 shows the overlap of these reflected pulses when $p=5$. In order to reproduce the asymptotic Airy intensity function

$$p\tau_0 \geq N' \tau_0 = 0.97 \mathcal{F}_R \tau_0 \quad (35)$$

If, as is usually the case, $p\tau_0 < N'\tau_0$, the superposition of the p pulses does not asymptotically approach the Airy function. The intensity maximum occurs at the response time for the p beams to interfere or at $p\tau_0$. From Equation (21) the intensity maximum is

$$I_{p_{max}}^t = I^t T^2 \left\{ \frac{1 - R^p}{1 - R} \right\}^2 \quad (36)$$

As the amplitude of the reflected beams decrease in an arithmetic progression after the time $p\tau_0$, the intensity decreases. It should be noted at all times, even after $t = p\tau_0$, that there are always p interfering beams and resolving power and finesse, remain constant, as seen from Equations (13) and (32). The intensity of

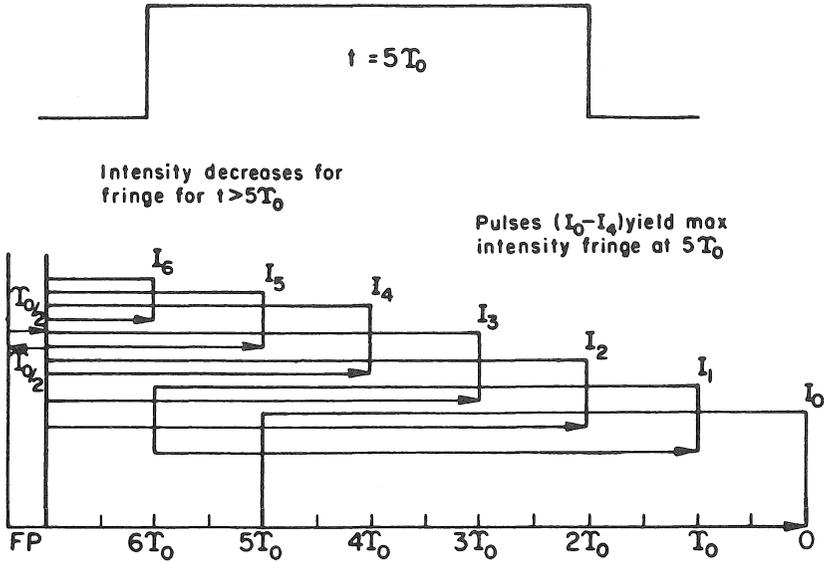


Fig. 4. Interference of 5 overlapping reflected pulses.

the signal decreases, but the resolving power and finesse are unchanged. The interference intensity is

$$I_p^t = I^t T^2 \left| \sum_{n=q}^{q+p-1} R^n e^{nj\delta} \right|^2, \quad q=0, 2p, 3p, \dots \tag{37}$$

in which for each fringe maximum there are only p interfering beams.

In the case in which the pulse has a width

$$\delta t = p\tau_0 > N' \tau_0 \tag{38}$$

then the asymptotic value of the Airy function has been reached and the appearance cannot be distinguished from an infinite number of interfering beams. It is known that $p \rightarrow \infty$ only for a perfectly monochromatic wave where $\Delta\nu \rightarrow 0$ and $\Delta\tau \rightarrow \infty$. Only a perfectly monochromatic coherent wave of infinite temporal extent can produce an infinity of interfering beams and the Airy intensity function. As a result, a very long pulse of width $\delta t > N' \tau_0$ cannot be distinguished from a perfectly monochromatic wave which is of infinite extent. A laser emits a quasimonochromatic wave, and in order to avoid ambiguity with respect to whether the signal is quasimonochromatic or perfectly monochromatic, it is necessary that

$$N' \tau_0 > \delta t > \tau_0 \tag{39}$$

or

$$\Delta\nu_{fsr}/N' < \delta\nu < \Delta\nu_{fsr} \tag{40}$$

In the actual experiment it may not be possible to adjust the FP so δt is an integer of τ_o , but by tilting the FP in the beam, δt can be made an integer multiple of the tilted FP delay time τ_d .

Finally, this discussion holds for a repetitive pulsed laser where $\Delta t \gg p\tau_o$ so the pulses are effectively isolated individually coherent pulses and are not coherent with each other.

Short Pulses

In this case the rectangular pulse is shorter than the FP delay time

$$\delta t < \tau_o \tag{41}$$

The initially transmitted and subsequently emitted reflected pulses are separated and never overlap. This means no interference is possible between the beams and no fringe pattern is observed. Very short laser pulses may not be analyzed. This gives a method of determining the temporal coherence length of a laser pulse. If the FP can be adjusted so a set of interference fringes are observed, and it is then scanned with the cavity length reduced until the fringes disappear, this gives the temporal coherence time. For a cavity with a spacing of 1.5 mm, a pulse as narrow as 10 ps can be measured. If the fixed spacing of a FP etalon is known, it can be used in a laser beam to set an upper limit on the temporal coherence time.

Pulse Train

Consider a mode-locked laser emitting a train of narrow rectangular pulses, in the train of which there are p pulses. The pulses have a width $\delta t = s\tau_o$ and a separation distance $\Delta t = q\tau_o$, in which s , p , and q are integers. The incident laser beam is monochromatic, collimated, and incident normally on the FP. Next, consider the three cases $\Delta t = \tau_o$; $\Delta t = q\tau_o$; and $\delta t < \tau_o$, and $\Delta t = q\tau_o$ and $\delta t > \tau_o$.

Case 1: $\Delta t = \tau_o$. Initially the FP is adjusted so the pulse spacing equals the FP delay time. On multiple reflection a single pulse produces a chain of non-overlapping pulses of decreasing amplitude. The pulses in any one train are coherent but pulses from different trains are incoherent and will not interfere. Now consider the interference at an instant of time $t_T = r\tau_o$ where $r < p$. The first r pulses and their reflected pulses interfere. This interference is equivalent to the interference of the initially transmitted and $(r-1)$ reflected beams, so the resultant intensity from Equation (15) is

$$I_r^t = I^i T^2 \left| \sum_{n=0}^{r-1} R^n e^{nj\delta} \right|^2 \tag{42}$$

in which $r \geq N'$ the asymptotic Airy function is observed and, as a result, a slow spatial scan of the interferometer will reproduce the spectrum of all the modes of the mode-locked laser.

The interferometer can also be scanned by tilting so $\Delta t = \tau_d$. One has gone from the filter to the fringe mode. In the filter mode the interferometer is wavelength scanned by changing the spacing d . If the interferometer is tilted in the beam, it can be wavelength scanned, as the spacing, $d \cos \theta$, is changed by

changing the angle θ . Thus by tilting the interferometer it is scanned in the fringe mode. Distinct fringes will thus be observed for light of wavelength λ_o where $\theta = \theta_m$ and one will have fringes of equal inclination. Neglecting phase shifts on reflection from the mirrors, from the basic FP equation in the m th order $m\lambda_o = 2d \text{ Cos } \theta_m = mc/\nu_o$ where $\Delta t = \tau_d = m/\nu_o$. Thus, perfect interference fringes are formed at the tilt angle θ_m for light of wavelength λ_o . At some other tilt angle $\theta_{m\pm g}$, at which $m + g$ is the interference order, a distinct set of fringes is formed where

$$\Delta t = \tau_{d_{m\pm g}} = \tau_o \text{ Cos } \theta_{m\pm g} = m/\nu_o \pm g/\nu_o \quad (43)$$

Thus, at the angle $\theta_{m\pm g}$ the center of successive interference pulses will advance or be retarded by an amount g/ν_o seconds. When the pulse width is δt , the $m + g$ order fringe will only be formed by the train of r pulses, if

$$r = \delta t/g/\nu_o = \nu_o \delta t/g \quad (44)$$

As an example, consider a train of 1 ps wide pulses at a frequency $\nu_o = 6 \times 10^{14}$ Hz and let the order change by $g = 10$, then

$$r = 1 \times 10^{-12} \times 6 \times 10^{14}/10 = 60 \text{ pulses}$$

This means that a train of 60 pulses may interfere. This is a large number and is adequate to produce the asymptotic Airy function. For a plane mirror interferometer cavity of reflectance $R = .90$, the finesses is $F_R = 31$. As the finesse for a finite number of interfering beams is nearly equal to the number of beams, then 60 beams is adequate.

Case 2: $\Delta t = q\tau_o$ and $\delta t < \tau_o$. The same pulse train as in the last section is analyzed, except $\delta t < \tau_o$ and $\Delta t = q\tau_o$. The FP is operated in the filter mode with a mode-locked laser. The pulses are shown in Figure 5 in which $q = 5$ and the interference is shown at the instant $t_T = 6 \Delta t$, so $r = 6$. The resultant intensity at this instant is

$$I^t = I^t T^2 \left| 1 + R^5 e^{5j\delta} + R^{10} e^{10j\delta} + R^{15} e^{15j\delta} + R^{20} e^{20j\delta} + R^{25} e^{25j\delta} + R^{30} e^{30j\delta} \right|^2$$

and in general

$$I^t = I^t T^2 \left| \sum_{n=0}^{rq} R^{nq} e^{nqj\delta} \right|^2 \quad (45)$$

After time $r \geq N'$ the asymptotic condition for the intensity is reached and the equation can be effectively considered an infinite sum and reduces to

$$A^t = A^t T \sum_{n=0}^{\infty} R^{nq} e^{nqj\delta} = A^t T \left\{ \frac{1 - R^{qj\delta}}{1 - R^q e^{qj\delta}} \right\}$$

The intensity is

$$I^t = I^t T^2 \left\{ \frac{1 + R^{2q} - 2R^q \text{Cos } q\delta}{1 - R^q e^{qj\delta}} \right\} = I^t T^2 \left\{ \frac{(1 - R^q)^2 + 4R^q \text{Sin}^2 (q \delta/2)}{1 - R^q e^{qj\delta}} \right\}$$

Now let

$$T_q = T^2 / (1 - R^q)^2 < T$$

and

$$F_q = 4R^q (1 - R^q)^2 < F \quad (46)$$

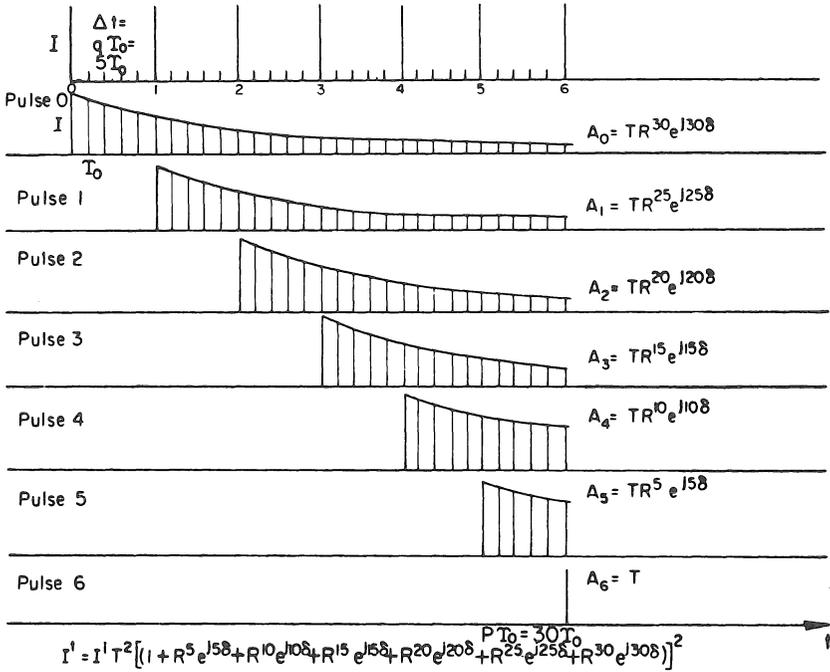


Fig. 5. Interference of a train of short pulses, $\Delta t = 5 \tau_0$ and $t_T = r \Delta t = 6 \Delta t$.

The intensity is

$$I^t = I^t T_q \left\{ 1 + F_q \text{Sin}^2 \left(q \delta / 2 \right) \right\} \tag{47}$$

This intensity pattern is different from the Airy function. The intensity maximum and minimum are

$$I_{\text{max}}^t = I^t T_q \tag{48}$$

and

$$I_{\text{min}}^t = I^t T_q \left\{ 1 + F_q \right\}$$

and the maxima occur when δ changes by $2\pi/q$, so the free spectral range is $\Delta\delta_{q,\text{fsr}} = 2\pi/q$. The half intensity is

$$I_{1/2}^t = I^t T_q F_q / 2 \left\{ 1 + F_q \right\} \tag{49}$$

and the half width phase angle is $\delta = 2m\pi \pm \Delta\delta_{1/2}/2$, so

$$I T_q F_q / 2 \left\{ 1 + F_q \right\} = I T_q \left\{ 1 + F_q \sin^2 \left(q \Delta\delta_{1/2}/4 \right) \right\}$$

Then

$$\sin^2 \left(q \Delta\delta_{1/2}/4 \right) = 2/F_q^2 + 1/F_q$$

Now as R approaches unity so $T + A = X$ is small then

$$\begin{aligned} F_q &= 4R^q / \left(1 - R^q \right)^2 = 4R^q / \left[1 - \left(1 - X \right)^q \right]^2 = 4R^q / \left[1 - 1 + qX - \dots \right]^2 \\ &= 4R^q / q^2 X^2 \end{aligned}$$

which is a large number. Then $2/F_q^2 \ll 1/F_q$ and if $(q\Delta\delta_{1/2}/4)$ is small, then

$$\Delta\delta_{1/2} = 4/q \sqrt{F_q}. \tag{50}$$

The reflectivity finesse becomes

$$\mathfrak{F}_R = \Delta \delta_{q,fsr} / \Delta \delta_{1/2} = 2\pi q \sqrt{F_q} / 4_q = \pi \sqrt{F_q} / 2. \tag{51}$$

Now, if $\Delta\delta_{q,fsr} = 2\pi/q$ then

$$\Delta \nu_{q,fsr} = \Delta \nu_{fsr}/q = 1/q \tau_o \tag{52}$$

and this means

$$\Delta t = q \tau_o = 1/\Delta \nu_{fsr} \tag{53}$$

This equation indicates that there is no overlap of spectra of different orders and spectroscopy with a spacing $\Delta t = q \tau_o$ is possible. Finally, the intensity function in Equation (47) has maxima whenever $\delta = \pm 2m\pi/q$ and it has q times more maxima than the Airy function.

Case 3: $\Delta t = q \tau_o$ and $\delta t > \tau_o$. Finally, consider the case in which the rectangular pulses have a width greater than the time delay of the interferometer. Let $\Delta t = q \tau_o$ and $\delta t = s \tau_o$. In Figure 6, which is the case in which $\Delta t = 6 \tau_o$ and $\delta t = 3 \tau_o$, shown at the instant $t_T = 6 \Delta t$ or $r = 6$. There are p pulses in the train. In this case $q=6$, $s=3$, and $r=6$ and the intensity is

$$\begin{aligned} I^t &= I^t T^2 \left| \left[1 + R^3 e^{3j\delta} \left(1 + R^6 e^{6j\delta} + R^{12} e^{12j\delta} + R^{18} e^{18j\delta} + R^{24} e^{24j\delta} + R^{30} e^{30j\delta} \right) \right. \right. \\ &\quad + R^4 e^{4j\delta} \left(1 + R^6 e^{6j\delta} + R^{12} e^{12j\delta} + R^{18} e^{18j\delta} + R^{24} e^{24j\delta} + R^{30} e^{30j\delta} \right) \\ &\quad + R^5 e^{5j\delta} \left(1 + R^6 e^{6j\delta} + R^{12} e^{12j\delta} + R^{18} e^{18j\delta} + R^{24} e^{24j\delta} + R^{30} e^{30j\delta} \right) \\ &\quad \left. \left. + R^6 e^{6j\delta} \left(1 + R^6 e^{6j\delta} + R^{12} e^{12j\delta} + R^{18} e^{18j\delta} + R^{24} e^{24j\delta} + R^{30} e^{30j\delta} \right) \right] \right|^2 \end{aligned}$$

If $\Delta t = q \tau_o$, $\delta t = s \tau_o$, and $s < q$ there is non-overlapping of the laser pulse and the resultant intensity at the instant $r\Delta t$ is

$$\begin{aligned} I^t &= I^t \left| T + T \left(R^q e^{qj\delta} + R^{(q-1)} e^{(q-1)j\delta} + \dots + R^{(q-s)} e^{(q-s)j\delta} \right) \right. \\ &\quad \left. \times \left(1 + R^q e^{qj\delta} + R^{2q} e^{2qj\delta} + \dots + R^{q(r-1)} e^{q(r-1)j\delta} \right) \right|^2 \end{aligned} \tag{54}$$

which becomes

$$\begin{aligned} I^t &= I^t T^2 \left| 1 + R^{(q-s)} e^{(q-s)j\delta} \left[\left(1 - R^{(s+1)} e^{(s+1)j\delta} \right) / \left(1 - R e^{j\delta} \right) \right] \right. \\ &\quad \left. \times \left[\left(1 - R^{qr} e^{qrj\delta} \right) / \left(1 - R^q e^{qj\delta} \right) \right] \right|^2. \end{aligned} \tag{55}$$

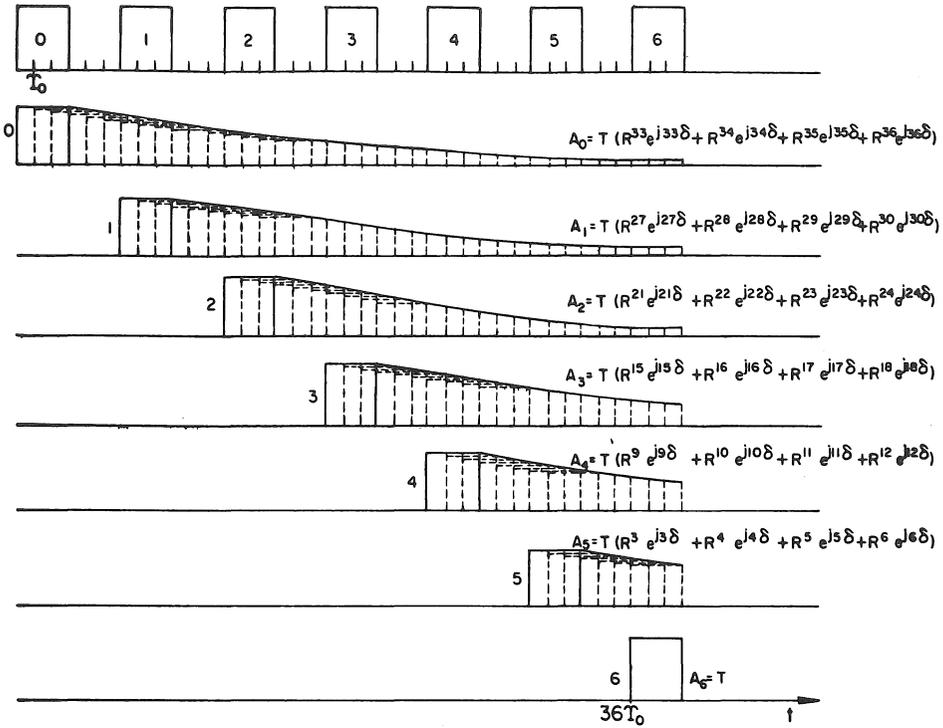


Fig. 6. Interference of a train of short pulses where the pulse width is greater than the FP delay time, $\Delta t = 6 \tau_0$, $t_T = r \Delta t = 6 \Delta t$, and $\delta t = 3 \tau_0$.

The nature of this intensity distribution is extremely complicated, as would be the expression for the finesse. There is one case in which this equation simplifies, the case in which $(q - s) = 1$. In this case, Equation (55) becomes

$$\begin{aligned}
 I^t &= I^r T^2 \left| 1 + R e^{j\delta} \left[\frac{1 - R^q e^{jq\delta}}{1 - R e^{j\delta}} \right] \right. \\
 &\quad \left. \times \left[\frac{1 - R^{r(s+1)} e^{r(s+1)\delta}}{1 - R^q e^{jq\delta}} \right] \right|^2 \\
 &= I^r T^2 \left| \frac{1 - R^{r(s+1)} e^{r(s+1)\delta}}{1 - R e^{j\delta}} \right|^2 \\
 &= I^r T^2 \left\{ \left[\left(1 - R^{r(s+1)} \right)^2 + 4R^{r(s+1)} \sin^2 \left(r(s+1)\delta/2 \right) \right] \right. \\
 &\quad \left. \div \left[\left(1 - R \right)^2 + 4R \sin^2 \left(\delta/2 \right) \right] \right\} .
 \end{aligned}$$

Now let

$$T_{r(s+1)} = T^2 \left(1 - R^{r(s+1)} \right)^2 / \left(1 - R \right)^2 < T$$

and

$$F_{r(s+1)} = 4R^{r(s+1)} / \left(1 - R^{r(s+1)} \right)^2 < F \tag{56}$$

Then

$$I^t = I^t T_r \left\{ \left[1 + F_{r(s+1)} \sin^2 \left(r(s+1) \delta/2 \right) \right] / \left[1 + F \sin^2 \left(\delta/2 \right) \right] \right\}. \quad (57)$$

This function is considerably different from the classical Airy function. Now if one writes $r(s+1) = k$ the function takes the form

$$I^t = I^t T_k \left\{ \left[1 + F_k \sin^2 \left(k \delta/2 \right) \right] / \left[1 + F \sin^2 \left(\delta/2 \right) \right] \right\} \quad (58)$$

and this equation has the same form as Equation (7), which was the basic intensity equation for a finite number of beams. Thus a set of fringes are formed when $(q-s) = 1$ and the fringes are separated by a single time delay $\Delta t - \delta t = \tau_0$. The fringes are broadened and have secondary maxima and minima between the principal maxima which occur at $\delta = 2m\pi$. These secondary maxima and minima occur at phase angles $\delta = (2m \pm n/k)\pi$ where $n = 1, 2, 3$,

$$I_{s_{\max}}^t = I^t T_k \left\{ \left(1 + F_k \right) / \left[1 + F \sin^2 \left(\delta/2 \right) \right] \right\} \quad (k \text{ odd}) \quad (59)$$

and the minima occur for k even and equal

$$I_{s_{\min}}^t = I^t T_k / \left[1 + F \sin^2 \left(\delta/2 \right) \right] \quad (k \text{ even}). \quad (60)$$

In the case in which $k = r(s+1) = N'$ the resultant intensity function asymptotically approaches the ideal Airy function.

Conclusions

The concepts presented in this paper have previously been presented by Roychoudhuri.¹ There may be slight differences in our equations and reasoning, but the intent is to present the problems related to the use of the FP interferometer and pulsed lasers. The problems presented in this paper may arise and students may not be aware of its cause, so it is called to their attention in an educational journal. Finally, this paper acquaints the student with more subtle points in the operation of the FP interferometer that can only be known by reading the sections on the FP in Born and Wolf.²

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Lidar and Its Applications

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Abstract: This paper discusses the uses of coherent lidar to remote sense the atmosphere. The uses have been wide spread from measuring wind shear at airports to the future plans to measure global wind patterns on a daily basis. These and many other applications will be discussed.

Introduction

The availability of high power and tunable lasers opened up the field of remote sensing. The ruby laser was first applied to the determination of cloud ranges and of pollutant layers in the atmosphere. The optical telescope in these measurements which detected the backscatter signal was a World War II search light mirror. It was adapted to be both the transmitter and receiver for the system. The time between transmission and return of a strong signal from a single ruby pulse gave the distance to the scattering layer.

The field of remote sensing has advanced since these crude experiments in the early 1960's. The transmitter lasers range over a spectrum of power levels and in some types of research they must be tunable. In the atmosphere lidar is used to measure aerosol backscatter, wind speed, atmospheric constituents at various ranges in the atmosphere, atmospheric temperature at different ranges, etc.

One area of extreme importance for the use of lidars is wind speed measurement. These measurements have ranged from a study of wind dispersal of industrial stack pollutants to the detection of wind shear at airports. It has been said that the short term local weather conditions are most influenced by the local wind patterns and movements. It will only be possible to predict short term weather accurately (several days in advance) when global wind patterns are known. Measurements of this type are planned from a satellite or system of satellites in north-south polar orbit and from the space station using a coherent Doppler lidar system. From these measurements global wind patterns will be known and the direction of global storms etc. can be traced and their motion predicted several days in the future.

Coherent Doppler Lidar Velocimetry

One of the most active areas for the use of lidar has been in the field of atmospheric wind measurements. An excellent review article on this area of research is that by Bilbro.¹ More general articles in this area and other uses of

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lidar have been written by Jelalian *et al.*² and Hinkley *et al.*³ Finally, a bibliography on all phases of coherent lidar has been assembled by Bilbro⁴ which covers references from 1963 to the end of 1986. Another excellent overview of lidar velocimetry is presented in another article by Bilbro.⁵

The first measurements of atmospheric winds were performed by Huffaker⁶ and he is as a result well known in the area of atmospheric Doppler lidar. There are many variations of the apparatus but to avoid strong water vapor absorption many employ either a cw or pulsed CO₂ laser for the transmitter.

The principle operation of the CO₂ heterodyne lidar system is that light passing through a medium with inhomogeneities is scattered, absorbed, backscattered, etc. The primary radiation backscattered toward the detecting optics is scattered from large particles like pollen, dust, aerosol particles, etc. These natural aerosols are in the Mie scattering regime but are small enough to be carried by the wind and their speeds at various levels of the atmosphere are a good indicator of the wind speed.

The transmitted laser radiation is polarized and for a common transmitter-receiver system it is right hand circular polarized. On backscatter by the aerosol the direction of polarization is rotated by 180° and it is left hand circularly polarized.

The beam backscattered from the aerosol exhibits a Doppler shift in frequency with respect to the incident beam and it is proportional to the particles velocity component parallel to the axis of illumination which is called the radial velocity. The direction of the shift is determined by the relative motion, a negative shift means the particle is receding from the source and a positive shift means it is approaching the source. The shift is

$$\Delta f = 2v/\lambda \quad (1)$$

where Δf is the Doppler shift, λ is the laser source wavelength, and v is the particles radial velocity.

In a pulsed system a small frequency stabilized laser is the master oscillator and its output is sampled and modulated. The sampled signal is set via a locking loop where a constant frequency offset is introduced so the local oscillator is frequency offset with respect to the master oscillator and the laser amplifier which is pumped by the master oscillator. This local oscillator is used as the reference signal for the heterodyne detection system. The remainder of the modulated signal from the master oscillator is a pump pulse for a large laser amplifier. In many systems a common telescope acts as the transmitting and receiving optics. A sketch of the cw and pulsed systems are shown in Figure 1. The cw system mixes signals of the same frequency and a homodyne detection system is used. In the cw system the cw CO₂ laser is also the local oscillator.

In both systems the output of the transmitting laser is vertically polarized and the Brewster angle window transmits this beam without reflection. The quarter waveplate produces right hand circularly polarized light which is transmitted. The received signal is left hand circular polarized and on passing through the quarter waveplate it is horizontally polarized. Horizontally polarized light on striking the Brewster angle window is totally reflected for it is polarized in the plane of the window. The Brewster window optically isolates the laser amplifier from the return signal which could destabilize it. The signal reflected from the

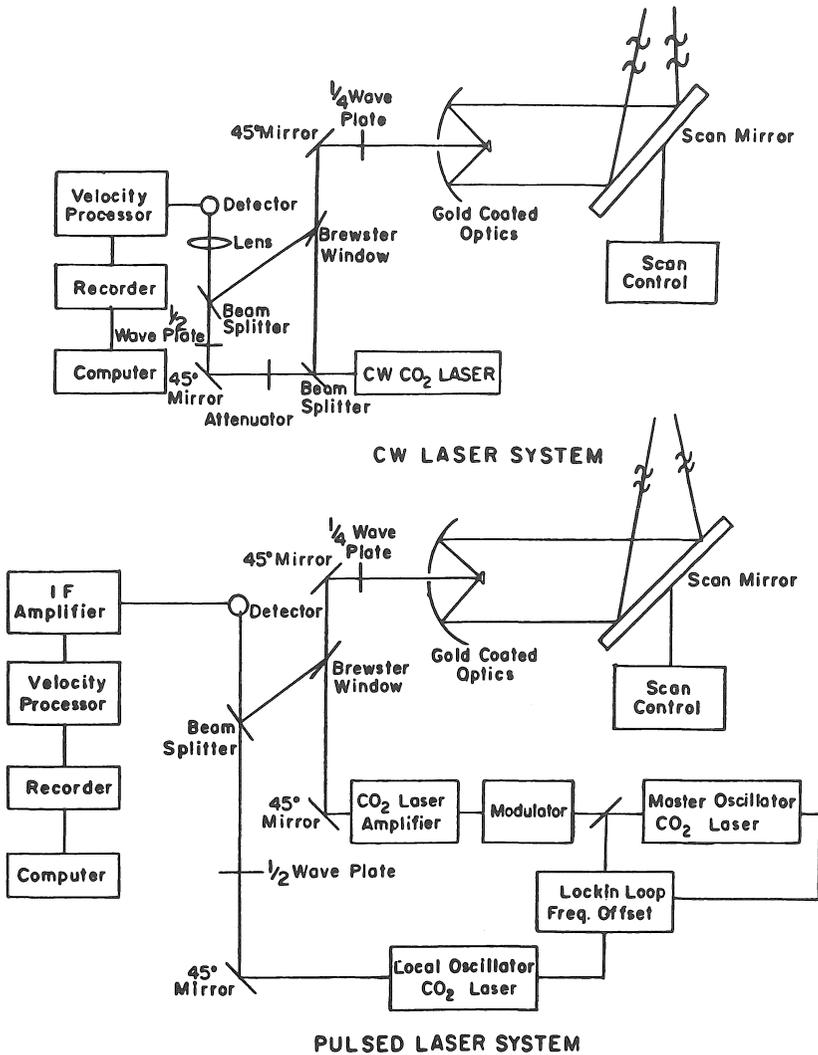


Fig. 1. CW and pulsed coherent Doppler lidar.

Brewster angle window is combined with the reference beam by the beamsplitter. The reference beam from the local oscillator is attenuated an appropriate amount and passes through a half waveplate which rotates the beam polarization by 90° so it becomes horizontally polarized. It now has the same polarization as the signal beam and they are combined at the beam splitter. The return signal beam and the reference beam are premixed in the detector. The remaining detector electronics measure the resultant frequency shift between them and from this data the velocity is evaluated.

If linear polarized light is used, it is necessary to have separate transmitting and receiving optics in order to isolate the transmitter laser from the return beam. The cw systems are limited by the size of the local laser oscillator. Much larger pulsed laser amplifiers can be developed.

Bilbro's article¹ shows a number of applications of lidar. One important application is the installation of Doppler lidar at major airports to measure wind speed and direction. This would be an important aid in determining if wind shear existed when an airplane was making an approach. The same lidar system can be installed on the side of the aircraft and scanned to determine wind speed in front of the aircraft. The data would be displayed on a small screen in the cockpit where wind speed would be shown as different colors on the display. Direction could not be determined from this data but vertical gradients would be seen on the display.

The Doppler lidar has been mounted on a mobile trailer and has been used to measure the velocity profile in dust devils in the desert. A more practical application has been to measure aircraft wake vortex on landing. These vortices have caused difficulty for small planes landing after a large aircraft. The same mobile lidar has been used to study industrial stack emission dispersal by the wind. At one time it was felt that high stacks could better disperse the pollutants and reduce the damage to the environment.

An aircraft mounted lidar has been used to measure wind profiles in severe storms by flying parallel to a strong weather front. The system in the aircraft has also been used to measure clear air turbulence which has been a problem to aircraft flight.

In the future coherent Doppler lidar will measure global wind patterns on a daily basis. This will be done by placing a lidar in a north-south polar orbit so the entire daily wind profile can be mapped. The earth rotates under the polar satellite orbit so a system could measure global wind patterns. This system is called LAWS (laser wind sensor). An entire issue of Applied Optics⁷ has been devoted to the discussion of this system and related satellite based systems.

Beta Lidar

The cw CO₂ lidar systems have found use in the measurement of the aerosol backscatter coefficient over a limited range. These lidar are called beta lidar and are detuned from any natural absorption frequency of atmospheric gases so molecular absorption is minimal. The detected signal is the Mie backscatter signal from the aerosol. The range of cw lidar are limited but in an aircraft flight the aerosol content can be measured at various levels of the atmosphere. The accurate measurement of beta (β) depends on a very accurate calibration of the system from an accurately calibrated target. The lidar signal is backscattered from this calibrated target over a fixed and known path and the signal is backscattered from the atmosphere. The magnitude of these signals are compared in order to determine β where the reflectivity of the target in backscatter is well known by comparison with a standard target. In the fall of 1989 several different beta lidar are to be compared in a series of aircraft flights called GLOBE and the measurements will be taken all over the world.

In these experiments⁸ the lidar radiation is backscattered from a calibrated target generally at 45° to the incident beam.

As stated earlier the reflectance of the target at this angle is well known by comparison with a diffuse gold standard and the path of the calibration beam is well known. The backscattered signal from the target is measured. Then the lidar is directed into the atmosphere and for a modulated system the return signal from a definite range is recorded. The range is determined by the return time of the backscattered signal for $R = ct/2$.

The backscatter signal from the target is

$$S_t(t) = \left\{ \int_{c(t-\Delta t)/2}^{ct/2} \eta P_t(t-2R/c) \times \rho^* A/R_t^2 O(R_t) \times \exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right] \right\} dR \tag{2}$$

where S_t is the measured signal, $P_t(t-2R/c)$ is the power emitted by the laser which was emitted at a time $(t-2R/c)$ earlier, ρ^* is the calibrated target backscatter parameter where the target reflectivity is ρ and $\rho^* = \rho/\pi$, A/R_t^2 is the solid angle the target subtends at the receiver, A is the target effective area, η is the system efficiency, $O(R_t)$ is the overlap between the incident and the received beams, and

$$\exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right]$$

is the atmospheric extinction or loss of radiation over the target path. For a single receiver-transmitter system the attenuation over a short path is

$$\exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right] \approx 1.$$

For a rectangular pulse of width Δt then

so

$$\int_{C(t-\Delta t)/2}^{ct/2} P_t(t-2R/c) dR = c/2 \int_0^{\Delta t} P_t(t) dt = (c/2)E_{ot}$$

$$S_t(t) = (c/2)E_{ot} \rho^* A/R_t^2 \eta O(R_t) \exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right] \tag{3}$$

where E_{ot} is the laser pulse energy.

The signal received from the atmosphere is

$$S_a(t) = \beta(R_a) A/R_a^2 \eta O(R_a) \exp \left[-2 \int_0^{R_a} \gamma_a(r') dr' \right] \int_{c(t-\Delta t)/2}^{ct/2} P_a(t-2R/c) dR. \tag{4}$$

A slab of the atmosphere at $R_a = ct/2$ centered at $R_a = c/2(t-\Delta t)$ is sampled where the slab thickness is $c\Delta t/2$. Generally the laser pulse power is assumed constant over the slab so

$$S_a(t) = \beta(R_a) A/R_a^2 \eta O(R_a) \exp \left[-2 \int_0^{R_a} \gamma_a(r') dr' \right] c/2 E_{oa} \tag{5}$$

where $\beta(R_a)$ is the volume atmospheric backscatter coefficient, R_a is the range, $\gamma_a(r')$ is the atmospheric absorption coefficient, E_{oa} is the laser energy, and Δt is very nearly the initial pulse width where atmospheric broadening is neglected. The integral in equation (5) holds for a rectangular pulse only. The ratio of the calibration signal to the atmospheric signal allows $\beta(R_a)$ to be determined or

$$\frac{S_t}{S_a} = \frac{E_{ot} \rho^* A / R_t^2 O(R_t) \exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right]}{E_{oa} \beta(R_a) A / R_a^2 O(R_a) \exp \left[-2 \int_0^{R_a} \gamma_a(r') dr' \right]}$$

Assuming $E_{ot} \approx E_{oa}$, $\gamma_a \approx \gamma_t$, $R_t \approx R_a$, and $O(R_t) \approx O(R_a)$, then

$$\beta(R_a) = \frac{S_a \rho^*}{S_t} \quad (6)$$

A less extreme approximation may be made with the laser output monitored so E_{ot} may be corrected to equal E_{oa} . $O(R_a)$ and $O(R_t)$ may be evaluated from the lidar geometry. Generally,

$$\exp \left[-2 \int_0^{R_t} \gamma_t(r') dr' \right]$$

is taken as unity and a similar approximation is made for a short atmospheric path or γ_t and γ_a can be evaluated from other atmospheric data. For these approximations

$$\beta(R_a) = \left[\rho^* S_a O(R_t) k_t R_a^2 \right] / \left[S_t O(R_a) k_a R_t^2 \right]$$

where k 's are the evaluated extinct terms. The largest error in the measurement results from poor calibration of the target reflectivity.

DIAL Measurements

Another area of interest is the use of the lidar to determine molecular densities at various ranges in the atmosphere. These data are measured with a differential absorption lidar (DIAL). The paper of historical importance in this area of research is by Schotland.⁹ Some typical recent papers that develop the theory of the problem are by Zeuv *et al.*¹⁰ and Ansmann.¹¹⁻¹²

In the DIAL technique two lasers lidar is employed and a typical setup is sketched in Figure 2. In order to determine the range it is best to use pulsed or modulated lasers. Since a definite molecular species is sampled in the atmosphere, one of the lasers is tuned to the absorption frequency of this molecule (for a molecule this may be the center or peak of an absorption band). The other laser is tuned off-line. The on-line frequency is designated ν_1 and the off-line frequency is ν_2 . A delay is introduced between the pulses from the two lasers. The maximum delay must be much less than 10 ms so the atmosphere turbulence does not change appreciably between the two samplings. A typical pulse frequency for the lasers should be 10 Hz and a delay of the order of tens of microseconds.

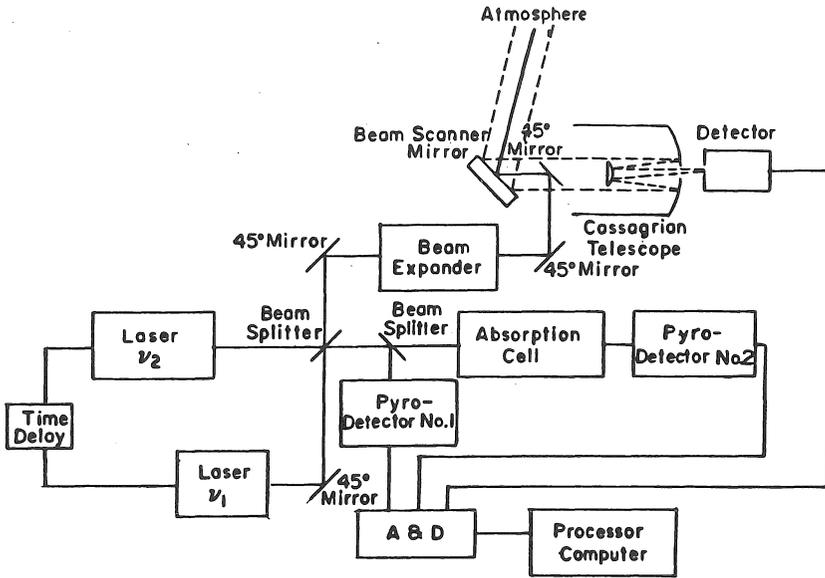


Fig. 2. Two laser DIAL lidar systems.

The outputs of the lasers are combined at a 50/50% beam splitter and a portion of each signal is directed into a pyroelectric detector and an absorption cell. The beams directed into the first pyroelectric detector monitors the laser beam intensities and may be used to stabilize them. The beam directed into the absorption cell allows one to tune the on-line laser for maximum absorption and to detune the off-line laser. At the 50/50% beam splitter the remainder of both beams are directed into the atmosphere with a time delay between the on-line and off-line lasers.

The off-line radiation undergoes predominately Mie scattering from the aerosol and the on-line radiation undergoes both Mie scattering and molecular absorption. The absorbed line undergoes Rayleigh scattering and the emitted radiation shows Doppler broadening. In general, the return signal is

$$S_i(\nu, R) = P_0 dR \eta T_i^2(R) O(R) A/R^2 \left\{ \beta_{M}(R) \int_0^\infty h_i(\nu, R_0) \tau_i^2(\nu, R) d\nu + \beta_{R}(R) \int_0^\infty \left[\int_0^\infty h_i(\nu', R) \tau_i(\nu', R) b(\nu - \nu', R) d\nu' \right] \tau_i(\nu, R) d\nu \right\} \quad (8)$$

where dR is the sample layer thickness at range R , P_0 is the laser incident beam power, η is the system efficiency, $O(R)$ is the overlap between the transmitter-receiver optics. Also

$$T_i = \exp \left[- \int_{R_0}^R \gamma_i(r) dr \right] \quad (9)$$

is the atmospheric extinction produced by all effects, except the absorption, and

$$\tau_i = \exp \left[- \int_{R_0}^R \alpha_i(r) dr \right] \tag{10}$$

is the attenuation of the signal by atmospheric absorption. The Mie and Rayleigh volume backscatter coefficients are β_{iM} and β_{iR} and $h_i (\nu, R_0)$ is the normalized laser line shape at the laser and the perturbed emission line shape is

$$h_i (\nu', R) \tau_i (\nu', R) b (\nu - \nu', R) \tag{11}$$

effected by pressure and Doppler broadening where in the atmospheric Doppler broadening is the principle effect.

The power in the on-line and off-line signals are

$$S_2 (R) = [P_0 dR T_2^2 (R) \eta O(R) A/R^2] \times \left\{ \beta_{2M}(R) \int_0^\infty h_2 (\nu, R_0) \tau_2^2 (\nu, R) d\nu \right\} \tag{12}$$

and

$$S_1 (R) = [P_0 dR \eta T_1^2 (R) O(R) A/R^2] \times \left\{ \beta_{1M}(R) \int_0^\infty h_1 (\nu, R_0) \tau_1^2 (\nu, R) d\nu + \beta_{iR}(R) \int_0^\infty \left[\int_0^\infty h_i (\nu', R) \tau_i (\nu, R) b(\nu - \nu', R) d\nu' \right] \tau_i (\nu, R) d\nu \right\} \tag{13}$$

Under the conditions cited in Ansmann's paper, assuming the absorption is small, then the absorption integral becomes

$$\int_{R_1}^{R_2} \alpha_i (r) dr = N(\bar{R}) \sigma (\nu, R_1, R_2) dR. \tag{14}$$

Now define

$$A_i(R) = \int_0^\infty h_i (\nu, R_0) \tau_i (\nu, R) d\nu \tag{15}$$

and

$$B_i(R) = \int_0^\infty k_i (\nu, R_0) \tau_i (\nu, R) d\nu \tag{16}$$

where the two ranges of sampling are R_1 and R_2 and the normalized line shaped after passing through a range R of the atmosphere is

$$h_i(\nu, R) = \frac{1}{A_i(R)} h_i(\nu, R_0) \tau_i(\nu, R)$$

Now

$$k_i(\nu, R) = \left\{ \beta_{iM}(R) h_i(\nu, R) + \beta_{iR} \int_0^\infty h_i(\nu', R) b(\nu - \nu', R) d\nu' \right\}, \tag{17}$$

Then

$$S_i(R) = \left\{ P_0 \int dR T_i^2(R) \eta(O(R) A_i(R) B_i(R) A) \right\} / R^2 \tag{18}$$

The natural logarithm of the ratio of powers is

$$\ln \left\{ \frac{S_1(R_1) S_2(R_2)}{S_1(R_2) S_2(R_1)} \right\} = \ln \left\{ \frac{A_1(R_1) A_2(R_2)}{A_1(R_2) A_2(R_1)} \right\} + \ln \left\{ \frac{B_1(R_1) B_2(R_2)}{B_1(R_2) B_2(R_1)} \right\} \tag{19}$$

Now

$$A_i(R_2) = A_i(R_1) \Delta A_i(R_1, R_2) \tag{20}$$

where

$$\Delta A_i(R_1, R_2) = \int_0^\infty h_i(\nu, R_1) \delta\tau(\nu, R_1, R_2) d\nu$$

and

$$\delta\tau(\nu, R_1, R_2) = \exp \left[- \int_{R_1}^{R_2} \alpha_i(r') dr' \right].$$

Similar expressions may be written for $B_i(R)$. Then under the condition of small absorption, the exponentials reduce to

$$\exp \left[- \int_{R_1}^{R_2} \alpha_i(r') dr' \right] = 1 - \int_{R_1}^{R_2} \alpha_i(r') dr' = 1 - N(\bar{R}) \sigma_i(\nu_i, \bar{R}) dR \tag{21}$$

When all these approximations are employed, the power ratio equation yields the molecular species at range R for the molecule sampled by the on-line frequency or

$$N(\bar{R}) = \left\{ \ln \left[\frac{S_1(R_1) S_2(R_2)}{S_1(R_2) S_2(R_1)} \right] \right\} / \left\{ 2 \left[\sigma_1(\nu_1, \bar{R}) - \sigma_2(\nu_2, \bar{R}) \right] dR \right\} \tag{22}$$

where $N(\bar{R})$ is the molecular density at mean range \bar{R} , $\sigma_1(\nu_1, \bar{R})$ and $\sigma_2(\nu_2, \bar{R})$ are the absorption coefficients at mean range \bar{R} for the on- and off-line radiation, and for a rectangular $dR = c\Delta t/2$.

If the molecular density is determined, then by scanning the atmospheric molecular line shape by tuning the on-line radiation the nature of the broadening can be determined and depending on the range in the atmosphere it most likely Doppler broadened. This information may be used to determine the temperature of the atmosphere at range R since the absorption coefficient or shape depends on the pressure and temperature.

Other Uses of Lidar

The lidar has found a number of military applications. In these problems it is desirable to use the CO_2 laser in either the pulsed or cw forms. The scanned

signal from a cw CO₂ lidar can be used to trace the profile of a distant scatterer. The images of tanks, artillery, etc. can be distinctly outlined and range determined. The lidar has been mounted on both helicopters and aircraft and the backscattered signal has been analyzed on a computer and outline of the telephone and electrical wires can be detected. The same lidar when small high volume computer is developed will be used on cruise missiles which follow the ground terrain. The lidar is the backbone of any SDI system. Scanned lidar placed in synchronous orbits about the earth will detect the rise of slow-burn strategic missiles and after separation the decoys and real warheads. For the new generation fast-burn missile only decoys or warheads can be destroyed. These lidars detect the weapon and the computer plots the trajectory so the kinetic weapons from satellites in low orbits can be directed to kill the warhead.

The lidar has for years been used to determine target ranges. In many applications it has been used in alignment procedures. In the future one can see the lidar supplementing the radar systems to assist in aircraft landings. It could be used to guide cars and trucks on highways to reduce accidents and on railways it could take over much of the control.

Conclusions

The lidar is becoming a part of our daily lives without our even being aware of it. Its future has been established in the military. Several of these applications are being or have been incorporated in our daily lives. The lidar is the main tool in sensing the atmosphere. In the future it will make possible reliable extended weather forecasts and this alone will be an enormous benefit to the economics of all nations of the world.

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Composite Graph Coloring Algorithms

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Abstract: Two basic types of heuristic algorithms for the composite graph coloring problem, vertex-sequential algorithms and color-sequential algorithms, were investigated as a function of number of vertices, edge density, and chromaticity distribution. Neither type proved to have superior average performance in all cases. However, the vertex-sequential algorithms performed superior to the color-sequential algorithms for a small number of vertices, but became progressively worse for increasing number of vertices. The opposite was true for color-sequential algorithms. The point at which the color-sequential algorithms became superior occurred for smaller n as the edge density became larger. This was true for all chromaticity distributions, but the cross-over point varied with the distribution.

Key words: Graph coloring, composite graph, vertex-sequential, color-sequential

Introduction

Consider a finite, undirected, loopless graph $G(V,E,C)$ in which V and E are the vertex and edge sets respectively and C is the list of vertex chromaticities. More specifically, $V = \{v_i\}$ is a finite set of elements called vertices which are connected by elements from the edge set $E = \{(v_i, v_j) : i \neq j\}$. Necessarily, E is a finite set of unordered pairs. The set of integers is denoted by Z and the set of positive integers by Z^+ . A sequence of consecutive integers is represented by $I[a,b]$ where $I[a,b]$ denotes the set of integers in the closed interval $[a,b]$. The notation $\langle u,v \rangle$ denotes an ordered pair. Associated with each vertex $v_i \in V$ is a positive integer $c_i \in C$ called the vertex chromaticity or simply the chromaticity of vertex v_i . The graph G is said to be composite if $c_i \neq c_j$ for some i and j . The number of edges emanating from vertex v_i is referred to as the degree of v_i . The chromatic degree of v_i is defined to be

$$cd_i = c_i + \sum_{j \in A_i} c_j$$

where $A_i =$ set of vertices adjacent to v_i . The graph G is K -colorable if for each vertex v_i there exists a set of c_i consecutive positive integers from the set $\{1,2, \dots, K\}$ such that no two adjacent (connected) vertices have an integer in common. The chromatic number of G is the minimum value of K such that G is K -colorable. Finally, the composite graph coloring problem (CGCP) is the problem of finding the chromatic number of a composite graph G .

It has been shown by Karp [1972] that the standard graph coloring problem is NP-complete. Since the composite graph coloring problem is a generalization of that problem, it is also NP-complete. Therefore, heuristic methods must be used to solve most practical applications which are modeled as composite graph coloring problems. Practical applications include the scheduling problem in which the tasks to be scheduled are of unequal duration. This study investigates two basic types of heuristic algorithms for the composite graph coloring problem, vertex-sequential algorithms and color-sequential algorithms.

Application of Composite Graph Coloring

Figure 1 illustrates the composite graph coloring model of a typical application in which n tasks (represented by vertices) desire to operate in parallel; however, certain tasks need to share a common resource such as particular hours of the day. The edges between two tasks indicate that the tasks cannot use a shared resource simultaneously. The number in the bracket above each vertex represents the number of consecutive units of a shared resource that is needed to accomplish the task. The composite graph coloring problem then is to assign the desired number of consecutive units of resource to each task in such a way that no two adjacent tasks have a particular unit of resource (e.g., hour of the day) in common while minimizing the total number of units of resource.

In Figure 1,

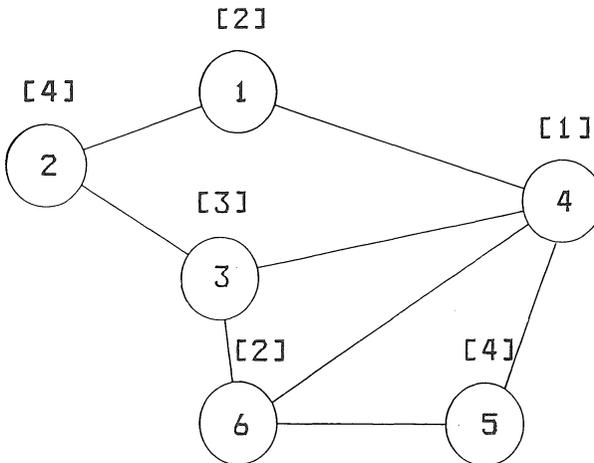


Fig. 1. Finite Undirected Graph with no Loops

$$\begin{aligned}
 V &= \{v_1, v_2, \dots, v_6\} = \{1, 2, 3, \dots, 6\} \\
 E &= \{(v_1, v_2), (v_1, v_4), (v_2, v_3), (v_3, v_4), \dots, (v_5, v_6)\} \\
 C &= \{c_1, c_2, \dots, c_6\} = \{2, 4, 3, 1, 4, 2\}
 \end{aligned}$$

Let k_i represent the set of consecutive positive integers assigned to vertex i ($i = 1, 6$). The assignment

$$\begin{aligned}
 k_1 &= \{1, 2\} & k_2 &= \{3, 4, 5, 6\} & k_3 &= \{7, 8, 9\} \\
 k_4 &= \{3\} & k_5 &= \{4, 5, 6, 7\} & k_6 &= \{1, 2\}
 \end{aligned}$$

illustrates that the graph is 9-colorable. A coloring that gives the chromatic number of G (optimal coloring) is:

$$\begin{aligned}
 k_1 &= \{5, 6\} & k_2 &= \{1, 2, 3, 4\} & k_3 &= \{5, 6, 7\} \\
 k_4 &= \{3\} & k_5 &= \{4, 5, 6, 7\} & k_6 &= \{1, 2\}
 \end{aligned}$$

Thus, if resource is hours of the day, then this coloring would yield the schedule in Figure 2.

HOUR \ TASK	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							

Fig. 2. Optimal Schedule

Vertex-Sequential Coloring Algorithms

Vertex-sequential coloring algorithms arrange the vertices of the composite graph in some order and then sequentially assign the vertices in this order the lowest possible sequence of consecutive integers (colors). For example, the vertices may be ordered from highest chromaticity to lowest chromaticity and then the lowest possible sequence of consecutive integers successively assigned to each vertex without using an integer that has already been used at an adjacent vertex. If the sequence of integers assigned to a vertex contains an integer which is greater than any assigned to previous vertices, an interchange technique can be applied. The interchange technique would try to interchange some or all of the integers of the current vertex and a vertex adjacent to the current vertex to

prevent the use of a new color. More specifically, the vertex-sequential with interchange algorithm follows:

Suppose that a composite graph $G = \langle V, E, \Phi, C \rangle$ is to be colored by a vertex-sequential with interchange (VSI) coloring algorithm and a coloring F is being generated. The vertices of G are arranged in the order $v_1, v_2, v_3, \dots, v_n$. Suppose the first $k - 1$ vertices have been assigned sequences of colors and v_k is the next vertex to be colored.

$$\text{Let } M = \max \left\{ \bigcup_{i=1}^{k-1} F(v_i) \right\}$$

be the highest color assigned to the previous vertices.

$$\text{Let } p = \min \{i \in Z^+ : I[i, i + C_k - 1] \cap F(v_j) = \emptyset\}$$

when v_j is adjacent to v_k for $j \in [1, k - 1]$. The VSI algorithm assigns the color sequence with initial color p to v_k , that is,

$$F(v_k) = I[p, p + C_k - 1].$$

If $p + C_k - 1 \leq M$, then the algorithm proceeds to color v_{k+1} . Otherwise, the interchange technique is applied to attempt to reduce the number of colors currently being used in the coloring. A description of the interchange technique is given below.

1) Determine a set P of candidate initial colors for the vertex v_k . A color is an element of P provided exactly one vertex adjacent to v_k has colors in the sequence $I[i, i + C_k - 1]$. $P = \{i \in I[1, p - 1] : \text{there is exactly one } j \in [1, k - 1] \text{ such that } v_j \text{ is adjacent to } v_k \text{ and } I[i, i + C_k - 1] \cap F(v_j) \neq \emptyset\}$. If $P = \emptyset$, then no interchange is possible and the algorithm proceeds to color v_{k+1} . Let us assume $P \neq \emptyset$.

2) Determining possible recolorings of v_k and an adjacent vertex for each $i \in P$. For each $i \in P$, define $J(i) \in [1, k - 1]$ where $v_{J(i)}$ is the vertex that is adjacent to v_k and $I[i, i + C_k - 1] \cap F(v_{J(i)}) \neq \emptyset$. For each $i \in P$, define $Q(i)$ to be the lowest permissible initial color for $v_{J(i)}$ if v_k were assigned the color sequence

$$I[i, i + C_k - 1]. \text{ For each } i \in P, Q(i) = \{r \in Z^+ :$$

$$I[r, r + C_{J(i)} - 1] \cap I[i, i + C_k - 1] = \emptyset \text{ and } I[r, r + C_{J(i)} - 1] \cap F(v_j) = \emptyset$$

when v_j is adjacent to $v_{J(i)}$ for $j \in [1, k - 1]$. Note that, for any $i \in P$, the vertices v_k and $v_{J(i)}$ could be validly recolored by redefining

$$F(v_k) = I[i, i + C_k - 1] \text{ and } F(v_{J(i)}) = I[Q(i), Q(i) + C_{J(i)} - 1].$$

3) Choose, if possible, a recoloring that reduces the number of colors being used for the coloring. Define

$$R = \{i \in P : Q(i) + C_{J(i)} < p + C_k\}. \text{ If } R = \emptyset, \text{ then any recoloring as described above will not reduce the number of colors currently used in the coloring. So, no interchange is possible and the VSI algorithm proceeds to color } v_{k+1}. \text{ Let us assume } R \neq \emptyset. \text{ Choose } i^* \in R \text{ such that}$$

$$\max \{i^* + C_k, Q(i^*) + C_{J(i^*)}\} =$$

$$\min \max \{i + C_k, Q(i) + C_{J(i)}\}.$$

$$i \in R$$

Recolor v_k and $v_{J(i^*)}$ by redefining $F(v_k) = I[i^*, i^* + C_k - 1]$ and $F(v_{J(i^*)}) = I[Q(i^*), Q(i^*) + C_{J(i^*)} - 1]$. The interchange technique is completed and the VSI algorithm proceeds to color v_{k+1} .

Clementson and Elphick [1983] presented four vertex-sequential heuristic algorithms for a composite graph.

- a) Largest first by chromaticity (LF1). Vertices are ordered in decreasing chromaticity order. Groups of vertices with equal chromaticities are sub-ordered in decreasing chromatic degree order.
- b) Largest first by chromaticity with interchange (LF1I). Same as LF1 with the added interchange technique.
- c) Largest first by chromatic degree (LF2). Vertices are ordered in decreasing chromatic degree order. Groups of vertices with equal chromatic degree are sub-ordered in decreasing chromaticity order.
- d) Largest first by chromatic degree with interchange (LF2I). Same as LF2 with interchange.

In this study four new vertex-sequential algorithms were introduced.

- a) Largest first by pigeonhole measure (LFPH). Vertices are ordered in decreasing static pigeonhole measure order.
- b) Largest first by pigeonhole measure with interchange (LFPHI). Same as LFPH with interchange added.
- c) Largest first by chromaticity times degree (LFCD). Vertices are ordered in decreasing order according to the product of a vertex's chromaticity and its degree.
- d) Largest first by chromaticity times degree with interchange (LFCDI). Same as LFCD with interchange added.

The LFPH and LFPHI algorithms are based on pigeonhole measures developed by Roberts [1987].

To discuss how the pigeonhole measures are obtained from the pigeonhole principle described by Tucker [1980], the assumptions to be used need to be set forth. Let us assume a composite graph $G = \langle V, E, \Phi, C \rangle$ is partially colored and U is the set of uncolored vertices. Let M be the highest color that we wish to use in the coloring of G . This is a goal which may or may not be attained. To continue coloring G , a vertex is to be selected from U to be colored next. For each uncolored vertex $v_k \in U$, define an adjacent colors bit array, $A(v_k)$, as follows: for each $j \in I[1, M]$, if a vertex adjacent to v_k has been assigned the color j , then $A(v_k)[j] = 1$; otherwise, $A(v_k)[j] = 0$. The term *gap* will be used to describe a maximal contiguous sequence of zeroes in an adjacent colors bit array. For the following discussion, v_k is assumed to be any uncolored vertex.

If a gap in $A(v_k)$ has length greater than or equal to C_k , then some of the colors corresponding to the gap could be used to color the vertex v_k . But if some vertices adjacent to v_k are colored prior to v_k , then the gaps may become smaller and v_k may possibly no longer be able to be colored with colors less than or equal to M . We desire to find a condition to indicate when a vertex v_k is guaranteed to be able to be colored with colors less than or equal to M regardless of what colors are eventually assigned to the remaining uncolored adjacent vertices.

If, after the vertices adjacent to v_k are colored, the average length of a gap is greater than $C_k - 1$, then there is a gap of length at least as large as C_k and

consequently the vertex v_k can be colored with colors less than or equal to M . We will find a lower bound on the average length of the gaps after the adjacent vertices are colored. If this lower bound is greater than $C_k - 1$, then v_k will be able to be colored with colors less than or equal to M regardless of the colors to eventually be assigned to the uncolored adjacent vertices.

Let F be any partial coloring of G in which the vertices in $V - U$ have the same colors assigned by the partial coloring previously described, the vertices adjacent to v_k have been colored, and v_k has not been colored. Let $B(v_k)$ be the adjacent colors bit array for v_k for the partial coloring F . Define g^* to be the average length of a gap in $B(v_k)$, that is,

$$g^* = \frac{\text{number of zeroes in } B(v_k)}{\text{number of gaps in } B(v_k)} .$$

(if the number of gaps in $B(v_k)$ is 0, assume $g^* = 0$.) Now, for the use of the pigeonhole principle, consider the zeroes in $B(v_k)$ as being stored in the gaps in $B(v_k)$. If there are any gaps in $B(v_k)$, then there must be a gap with length at least $\lceil g^* \rceil$. If $\lceil g^* \rceil \geq C_k$ or equivalently $g^* \geq C_k - 1$, then v_k can be colored with colors less than or equal to M . To obtain a lower bound on g^* , we find a lower bound on the above fraction.

$$g^* \geq \frac{\text{minimum possible number of zeroes}}{\text{maximum possible number of gaps}} .$$

For each uncolored adjacent vertex that is subsequently colored, a gap in $A(v_k)$ could become two smaller gaps yielding a possible net gain of one gap per uncolored adjacent vertex. So, the maximum possible number of gaps is the current number of gaps in $A(v_k)$ plus the number of uncolored adjacent vertices. The minimum possible number of zeroes is M reduced by the number of distinct colors already assigned to vertices adjacent to v_k and the number of distinct colors that could possibly be assigned to the uncolored vertices adjacent to v_k . In the worst case, each uncolored adjacent vertex could be assigned colors not previously assigned to other adjacent vertices. In this case, the number of colors used for the presently uncolored adjacent vertices would be the sum of the chromaticities of these vertices. Define the following identifiers for the quantities mentioned above:

- UC(v_k): the number of distinct colors currently assigned to vertices adjacent to vertex v_k
("used colors")
- RCD(v_k): the sum of the chromaticities of the uncolored vertices adjacent to vertex v_k
("reduced chromatic degree")
- NG(v_k): the number of gaps in the adjacent colors bit array of vertex v_k
("number of gaps")
- RD(v_k): the number of uncolored vertices adjacent to vertex v_k
("reduced degree")

If $NG(v_k) + RD(v_k) \neq 0$, define

$$L(v_k) = \frac{M - (UC(v_k) + RCD(v_k))}{NG(v_k) + RD(v_k)}$$

If $NG(v_k) + RD(v_k) = 0$, the colors to be eventually assigned to vertex v_k must all be greater than M . In this case, define $L(v_k) = -\infty$. $L(v_k)$ is a lower bound on g^* that is independent of the colors that are eventually to be assigned to the uncolored vertices adjacent to v_k . If $L(v_k) > C_k - 1$, then $g^* > C_k - 1$ and $\lceil g^* \rceil \geq C_k$. So, if $L(v_k) > C_k - 1$, then the vertex is “easy” to color.

We will refer to the quantity $C_k - 1 - L(v_k)$ as the floating-point pigeonhole measure of the vertex v_k , $FPH(v_k)$.

If $NG(v_k) + RD(v_k) \neq 0$, then

$$FPH(v_k) = \frac{(C_k - 1)(NG(v_k) + RD(v_k)) + (UC(v_k) + RCD(v_k)) - M}{NG(v_k) + RD(v_k)}$$

Otherwise, $FPH(v_k) = +\infty$. If $FPH(v_k) < 0$, the vertex v_k is “easy” to color. Notice that the sign of $FPH(v_k)$ is determined by the numerator of the fraction. We will refer to the quantity

$$(C_k - 1)(NG(v_k) + RD(v_k)) + (UC(v_k) + RCD(v_k))$$

as the pigeonhole measure of the vertex v_k , $PH(v_k)$. If $PH(v_k) > M$, then the vertex v_k is “easy” to color. $PH(v_k)$ can be interpreted as the highest color that could be assigned to an uncolored vertex adjacent to v_k while not leaving a gap of length C_k (taking into account the number of colors already assigned to vertices adjacent to v_k), that is, all present gaps and potential gaps from coloring the adjacent vertices being of length $C_k - 1$.

The largest-first-by-pigeonhole-measure (LFPH) coloring algorithm is a VS coloring algorithm that orders the vertices in decreasing static pigeonhole measure order. The static pigeonhole measure (SPH) of a vertex is the pigeonhole measure of the vertex for the conditions prior to coloring any vertices of the graph. The number of colors to be used in the coloring will be at least 1, so it is reasonable to consider $M \geq 1$. For a vertex v_k of the composite graph to be colored, the following quantities have the indicated values prior to coloring any vertices:

$$NG(v_k) = 1, UC(v_k) = 0, RCD(v_k) = cd_k - C_k, \text{ and } RD(v_k) = d_k$$

where d_k is the degree of vertex v_k and cd_k is the chromatic degree of vertex v_k . By substituting these values into the formula

$$PH(v_k) = UC(v_k) + RCD(v_k) + (C_k - 1)(NG(v_k) + RD(v_k))$$

we obtain

$$SPH(v_k) = cd_k + (C_k - 1)d_k - 1.$$

$SPH(v_k)$ is the maximum number of colors that can be used in a coloring without guaranteeing that a gap of length C_k appears in the adjacent colors bit array of the vertex v_k . This number of colors is attained if all colors assigned to

the vertices adjacent to v_k are distinct and the sequences of colors assigned to the adjacent vertices are separated, preceded, and followed by gaps of length $C_k - 1$. When coloring the composite graph, v_k can be colored with colors less than or equal to $\text{SPH}(v_k) + 1$.

Color-Sequential Coloring Algorithms

Starting with the color 1 as the current color, a color-sequential algorithm for the composite graph coloring problem assigns color sequences with the current color as the initial color to as many vertices as possible before proceeding to assign color sequences with the next possible initial color. Upon completion of assigning color sequences with initial color k to vertices of the composite graph, each remaining uncolored vertex is adjacent to at least one vertex that has been assigned the color j for $j \in I = \{1, 2, \dots, k\}$. The process proceeds recursively until all vertices are colored.

In this study four color-sequential algorithms RLF1, RLFD1, DYNPH and DYNFPH were introduced. Let U denote the set of all uncolored vertices, $U1$ the set of all uncolored vertices that are not adjacent to a vertex that has been assigned the current color, and $U2$ the set of all uncolored vertices that are adjacent to a vertex that has been assigned the current color.

In the RLF1 coloring algorithm, the first vertex to be assigned a color sequence with the current color as its initial color is selected from $U1$ according to the following criteria:

- 1) maximum chromaticity (primary) and
- 2) maximum chromatic degree in the uncolored subgraph U (secondary).

The remaining vertices to be assigned color sequences with the current color as their initial color are selected from $U1$ according to the following criteria:

- 1) maximum chromaticity
- 2) maximum $U2$ chromatic degree, and
- 3) minimum $U1$ chromatic degree (the chromatic degree in the subgraph $U1$).

The RLFD1 algorithm is the same as the RLF1 algorithm except in each place chromatic degree is used in the RLF1 algorithm, degree is used in the RLFD1 algorithm.

The dynamic-pigeonhole-measure (DYNPH) and the dynamic-floating-point-pigeonhole-measure (DYNFPH) coloring algorithms use the pigeonhole measure PH and the floating point pigeonhole measure FPH, respectively, as described in Roberts [1987], to determine the order in which the vertices of a composite graph are colored. For the LFPH and the LFPHI algorithms, the pigeonhole measure PH is calculated once for each vertex and is not modified during the coloring of the graph. Upon coloring a vertex, the dynamic pigeonhole measure algorithms update the pigeonhole measures of the uncolored vertices to reflect the effect of coloring the vertex. In the RLF1 and the RLFD1 algorithms, some of the measures that determine the next vertex to be colored are updated after the coloring of a vertex. The changes in these measures reflect the fact that a vertex has been colored but are not dependent upon the particular colors assigned to that vertex. The dynamic pigeonhole measures are dependent upon the particular vertices that are colored (through

the quantities RCD and RD) and upon the particular colors assigned to those vertices (through the quantities UC and NG).

In the DYNPH (DYNFPH) algorithm, a vertex with the largest PH (FPH) is selected to be the next vertex to be colored. After a vertex is colored, the PH (FPH) of each uncolored adjacent vertex is updated. Below is a pseudocode description of the DYNPH coloring algorithm in which V is the vertex set of the composite graph being colored and U is the set of uncolored vertices. Let M , the number of colors used to color the first $K - 1$ vertices, be zero initially.

Dynamic Pigeonhole Measure Coloring Algorithm

Select the initial value for M to be zero.

Initialize $PH(v)$ for each $v \in V$.

$U = V$.

WHILE $U \neq \emptyset$

 Select a vertex $v \in U$ such that

$PH(v) = \max \{PH(u) : u \in U\}$.

 Color the Vertex v with the lowest possible sequence of colors.

$U = U - \{v\}$.

 Update $PH(u)$ for each $u \in U$ such that u is adjacent to v .

 IF the highest color assigned to the vertex v is greater than M THEN

 Update M .

 Update the $PH(u)$ for each $u \in U$. (The color range has expanded. A new gap at the end of the color range may be created for some vertices).

 END IF

END WHILE

A description of the DYNFPH algorithm can be obtained by replacing the pigeonhole measure PH by the floating-point pigeonhole measure in the description of the DYNPH algorithm.

Comparison of Algorithms

The goal in comparing composite graph coloring algorithms is to identify the algorithm with minimum chromatic number as a function of edge density, chromaticity distribution, and number of vertices. Edge density represents the probability any given edge is in the graph.

The sample for this experiment consisted of 75 groups of random composite graphs $G(n,u,d)$, where

n : number of vertices = 100(100)500

u : edge density = .10(.05).20

d : chromaticity distribution

 TRP: truncated Poisson with parameter = 1.

 DNR: "down ramp" on [1,10]

 BIN: shifted Binomial

 UNI: Uniform on [1,10]

 UPR: "up ramp" on [1,10].

Each of the chromaticity distributions is discussed by Roberts [1987]. Each group of graphs (fixed n,u,d) consisted of 25 random graphs.

The particular distributions used in Figures 3-10 are the truncated Poisson

and the shifted Binomial. The TRP distribution is the truncated Poisson distribution with parameter $\lambda = 1$, namely,

$$P[X=k] = \frac{\lambda^k}{(e^\lambda - 1) (k!)} \quad k = 1, 2, 3, \dots$$

The BIN distribution is a shifted Binomial distribution,

$$P[X=k] = P[Y=k-1] \quad k \in [1, 10],$$

where Y is a random variable distributed according to a Binomial distribution with parameters $M = 9$ and $p = 0.5$.

The eight vertex-sequential and four color-sequential algorithms discussed earlier were compared over the 1875 graphs generated using the above criteria. Information recorded was:

- > Average number of colors/graph for each algorithm
- > Minimum and maximum number of colors used in the coloring of the 25 random graphs for each algorithm
- > The number of wins for each algorithm (the number of times the algorithm used no more colors to color a graph than any of the other algorithms).

Based on the results of the experiments, five of the algorithms, LF1I, LFPHI, LFCDI, RLF1, and RLFDI, consistently performed superior to the other seven algorithms. Thus, the performance of these five algorithms was analyzed with respect to the number of excess colors and the number of wins as the three parameters $n, u,$ and d varied. Figures 3-10 illustrate the trend in the performance of the algorithms under some of the parameter changes.

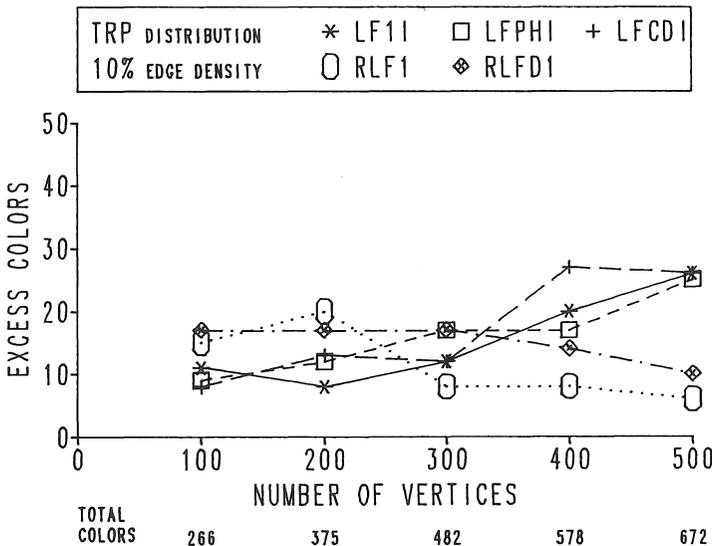


Fig. 3. Number of Excess Colors vs. Number of Vertices for Random Composite Graphs with $\mu = 0.10$ and $d = TRP$

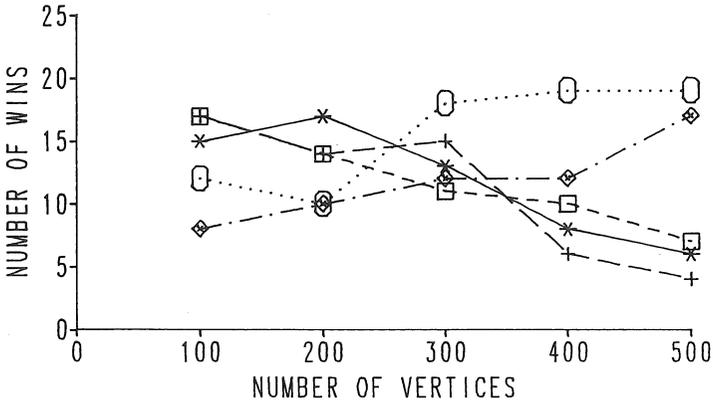


Fig. 4. Number of Wins vs. Number of Vertices for Random Composite Graphs with $\mu = 0.10$ and $d = TRP$

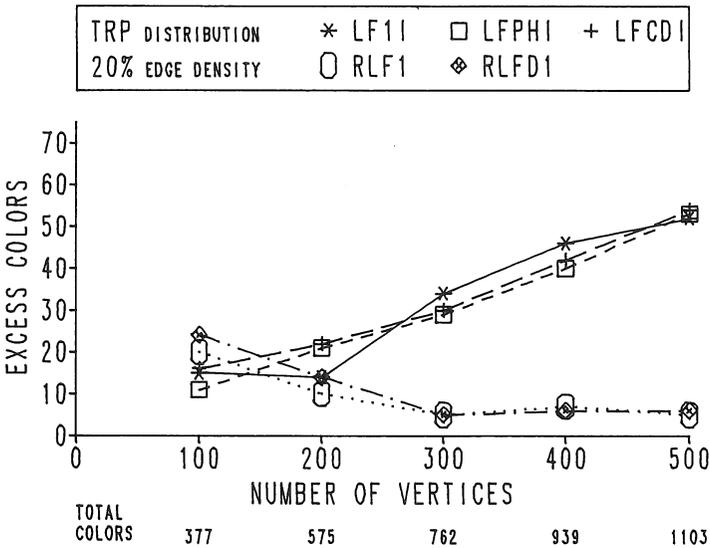


Fig. 5. Number of Excess Colors vs. Number of Vertices for Random Composite Graphs with $\mu = 0.20$ and $d = TRP$

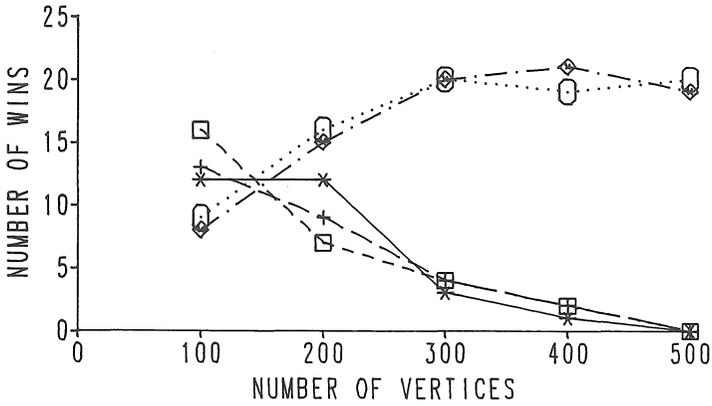


Fig. 6. Number of Wins vs. Number of Vertices for Random Composite Graphs with $\mu = 0.20$ and $d = TRP$

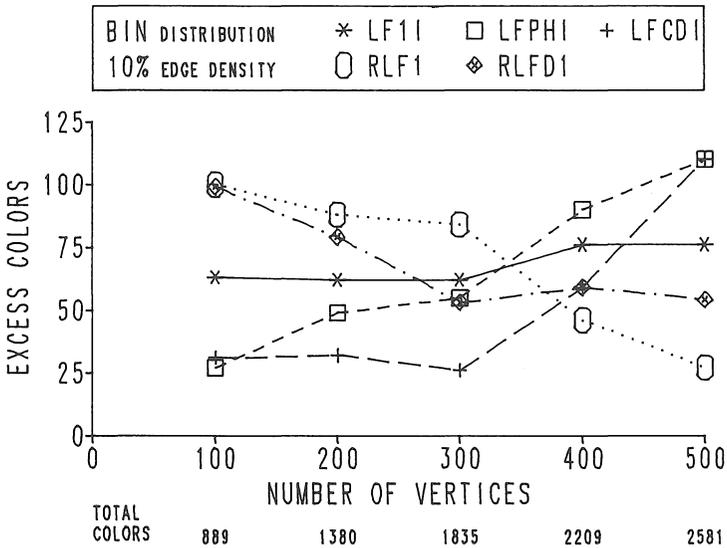


Fig. 7. Number of Excess Colors vs. Number of Vertices for Random Composite Graphs with $\mu = 0.10$ and $d = BIN$

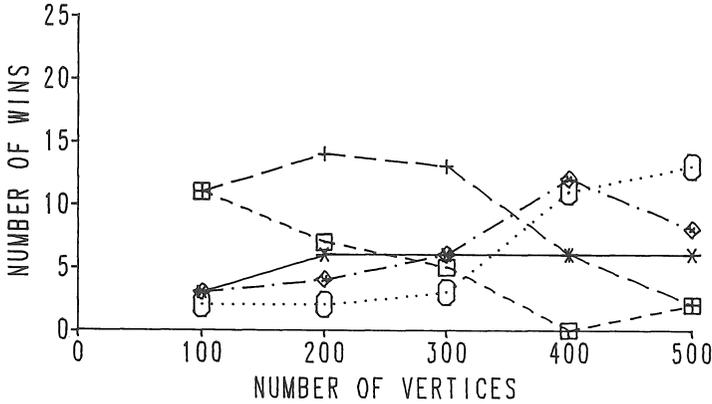


Fig. 8. Number of Wins vs. Number of Vertices for Random Composite Graphs with $\mu = 0.10$ and $d = \text{BIN}$

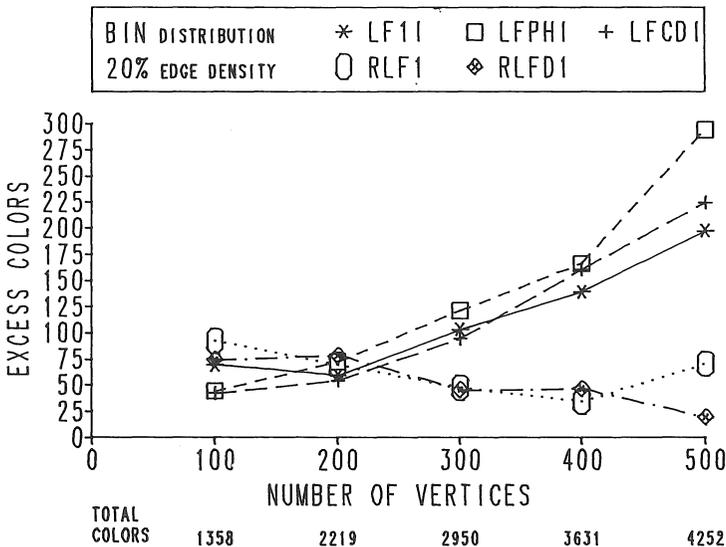


Fig. 9. Number of Excess Colors vs. Number of Vertices for Random Composite Graphs with $\mu = 0.20$ and $d = \text{BIN}$

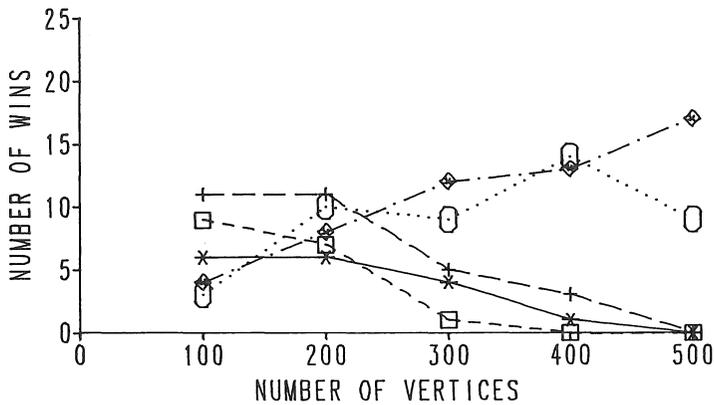


Fig. 10. Number of Wins vs. Number of Vertices for Random Composite Graphs with $\mu = 0.20$ and $d = \text{BIN}$

Conclusions

Based on the results of this experiment,

- > no one algorithm had superior average performance on all 75 groups of random composite graphs. However, the vertex-sequential algorithms (LF1I, LFPHI, and LFCDI) performed superior to the color-sequential algorithms (RLF1, RLFD1) for small n , but became progressively worse for increasing values of n . The opposite was true for the color-sequential algorithms. (See Figures 3-10).
- > the cross-over point, the point at which the color-sequential algorithms became superior, occurred for smaller n as the edge density u became larger. This was true for all chromaticity distributions, but the cross-over point varied with the distribution.

In summary, it is recommended that for a given graph $G(V,E,C)$, use the output graphs from Roberts [1987] to select the algorithm which has the best average performance.

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CIM: Integration of CAD/CAM/CAE Into the Manufacturing Environment

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Abstract: The integration of Computer Aided Design and Manufacturing software can be very puzzling. Each manufacturer must determine what is expected from a total system and integrate these "Islands of Automation" so that common databases eliminate duplication of effort and resulting inefficiencies. Only through the use of common databases can all areas of the Company truly achieve the productivity improvement possible.

Key words: CAD/CAM, integration, inventory, quality, design

Introduction

For several years, manufacturers have been bombarded with new acronyms describing the latest technology improvements to solve problems or enhance their capabilities. These cover the gamut from inventory systems such as Material Requirements Planning (MRP) to shop floor quality control tools such as Statistical Process Control (SPC). Sorting out all of these hardware or software systems and determining what is needed to suit a particular company's needs is very puzzling.

To be competitive on a worldwide basis requires that companies react quickly to meet tight schedules. They must be able to shorten the time from the design concept to production, and the designs must be "production friendly". Traditional methods of design by Product Engineering and "tossing the design" to Manufacturing no longer work.

Traditional manufacturing practices such as division of work by department no longer allow the company to be as responsive as they need to be to be competitive. With the technology that is available today, companies can become more responsive through the use of the computerized tools and techniques. However, integration of these tools and having systems that communicate with each other through common databases ensure that the total becomes greater than the sum of its parts.

Many periodicals we read today make statements that without this or without that, no company can truly have Computer Integrated Manufacturing (CIM). This is a misnomer in that each company's situation is different and not all of these tools are needed for a particular company's needs. Some companies produce high volume products whereas others require lower volumes with more catalog numbers to meet customer needs. In the latter situation, the fast turn-around time on specials may be more important to them than the feedback systems from highly automated equipment.

Each company must assess their needs and determine what is best in their situation.

The Systems

As companies have computerized over the last several years, most of their computerization has been isolated in different parts of the company and in effect have created "islands of automation". They increase productivity, but when integrated with others become even more productive.

The Shop Floor Control Systems

Most companies have had computerized business systems in place for many years. These business systems are primarily built around the inventory system of the company. They include systems to speed order entry, allow automatic generation of purchase orders, give inquiry means for people within the organization to track production, monitor inventory availability, and assure that customers' inquiries can be answered quickly.

Inventory planning tools such as MRP are extremely powerful and allow companies to plan their material many, many months in advance. Coupling this with today's Just-In-Time production philosophy allows a company to have the material available on the shop floor when it is needed and to minimize the amount of inventory between work stations. In addition, on-line production reporting systems give immediate feedback for inventory update as product is produced. This allows the inquiry systems to have the most up-to-date information available. The use of computer terminals throughout the company gives insight to production scheduling, Marketing for quotations to customers, Shipping to give realistic dates to customers, and to Purchasing to determine if revised supplier shipping dates will meet the goals required.

An additional shop floor system that is available to us today improves the feedback information on SPC systems. Systems are available to measure part variation to ensure that the critical part dimensions are within the specification allowed to ensure product integrity. These data entry stations give immediate feedback to the employee doing the measuring and allows Quality Assurance to have access to up-to-date information on the shop floor. These data can be gathered, sorted, manipulated and decisions made as to the success of the SPC program, which can be a measurement of the overall quality level.

Product Design Tools

From their inception, the tools available for computerized design have evolved from drafting to very powerful tools to create product geometry and allow analysis prior to the building of prototypes. With the product geometry stored on the computer systems it is possible for a company to be truly "paperless" and eliminate the need for hard drawings. Drawings that required the employee to read dimensions through smudged thumb prints, grease, and other grime. The use of terminals on the shop floor to view released drawings in Manufacturing ensures that the latest revision of drawing is available to the employee. This eliminates a variety of problems that we have all been too familiar with in the past—to have parts made only to find that they are not to the latest revision.

Computer-Aided Design Tools

With the use of Three-Dimensional Graphics and Solid Modeling, companies can now conceptualize and design products on the screens, eliminating

many prototyping iterations. The use of solid modeling is the intermediate step that allows you to not only conceptualized, but also to use the data generated to be used in designing and detailing the product in Design Engineering and pass on to Manufacturing for tooling design.

The use of solid modeling is a very powerful tool in that several design concepts can be evaluated on the screen between the design, manufacturing, and marketing people to determine what designs would be most usable in the field, and to determine what are the most manufacturable, as cost estimates can be made from these concepts. In addition, analysis tools can be used to determine how friendly this design can be in manufacturing.

Computer-Aided Engineering Analysis

By using the previously mentioned design tools to conceptualize and design in 3-D or solids, geometry is now ready to be passed to the software packages that allow preprototype analysis in problem solving. This again eliminates design and testing iterations previously required. Finite element analysis packages such as ¹ANSYS® and dynamic analysis packages such as ²ADAMS® can be run on a variety of hardware. These two design tools can minimize material yet maximize function.

Manufacturing Design Tools

Manufacturing engineers have similarly powerful tools. Their tools allow the actual generation of programs for Numerically Controlled (NC) equipment using the product geometry previously made in the product design area. The software systems used in the NC programming area allow the debugging of the programs to show the tool path on the graphic screen and ensure that no interference is made between the tool and the part geometry during the tool movements from one operation to the other.

In addition, the data can be transferred directly to the NC equipment so that this information is distributed without having to go to a hard copy or computer tape to operate the machine. Distributed Numerical Control ensures that the data are moved directly to the machine without the chance of it being destroyed. Electronic storage of these programs then allows the operator of the equipment to call up whatever programs are required to do the job on the machine tool.

Designing for Manufacture

Traditionally companies have fallen into the trap of designing products in Design Engineering and passing the design to Manufacturing so they can determine how to produce it. Using this traditional philosophy there are obviously many, many changes required when a design reaches the manufacturing area. This is where the revisions start—a product goes through several design iterations to ensure that it becomes production friendly.

Techniques are available to analyze designs prior to manufacturing and determine how cost-effective the design will be in production. Many are commonsense or philosophical in nature in that they require the product design people and the manufacturing engineering people to work in concert on a design. However, there are techniques to quantify assembly efficiency prior to their release. Such a system is the ³Boothroyd-Dewhurst *Design for Assembly System*®. This system evaluates individual parts and rates them as to their

assemblability. It assigns a design efficiency factor for a particular assembly or subassembly. This gives a bench-mark with which to look at other designs which may have fewer parts or incorporation of the function of several parts into fewer parts.

Variation Simulation and Analysis Software ⁴(VSAS)[®] evaluates tolerances statistically to determine the effect that their variation will have in production. This can be done as sophisticated as the company wishes it to be in that the capability of pieces of production equipment can be included in the variation simulation. It eliminates the problems in the past where tolerance stackup was the only tool used to determine whether or not something would assemble. This system goes beyond that and allows statistics to be used to determine if the possible overlapping of tolerances can be allowed without assembly problems.

A similar tool is Design of Experiments or Statistical Problem Solving (SPS) which also uses statistics to identify variables and their impact. It defines significant independent variables and dependent variables that in concert can cause problems. This method is most used on the shop floor but it can be used in the design phase as a very powerful tool.

To ensure a competitive product is being designed, product costing must be done throughout the design program. Cost Estimation programs are used to evaluate all design alternatives. They can be purchased as software packages or the company's costing system used for this purpose.

Integrators

As previously stated, all the described tools are valuable in their own right, but in total their value is even greater. By having stand-alone systems or "islands of automation," part geometry must be recreated many times before a product is manufactured. In addition, text such as bills of material must be recreated many times. This requires time and allows potential for errors. Integration into common or shared databases eliminates and simplifies these procedures. As an example, if the drawing bill of material is electronically moved to the manufacturing process sheet, it can be done without chance of error, as opposed to the manual methods.

IGES (Initial Graphics Exchange Specification)

A standard has been established to allow different graphics software systems to communicate by passing geometry through the IGES software. It reads one input and translates to a different output. This system has had some problems in the past with transfer of text, but in many cases today is being used quite satisfactorily for the passing of both geometry and text.

LAN (Local Area Network)

A local area network is an interconnected system which allows transfer of information between computers such as PC's or PC to mainframe or other hardware systems. This system allows communication between operators, data transmission, and common data usage between locations.

GT (Group Technology)

Computer Aided Drafting (CAD) drawing databases can now be categorized by attributes. Parts are assigned attributes that distinguish them from others by

some feature. This allows the cataloging of parts, fasteners, etc. by definition so they can be recalled for product standardization and simplification. This ensures that as new products are designed, existing parts are used and there is not a proliferation of design data. This is particularly useful in areas that have multiple dimensions for similar parts. In companies that require specials built to meet customer needs this allows a much faster recall of part geometry for the design phase.

These same or similar attributes can be assigned for use in manufacturing for routing sheet development, costing, capacity planning, and other applications. This improves productivity in all functional areas using common data.

CAPP (Computer Aided Process Planning)

This software assists in the setting up of new products or the revision of existing products. It allows the generation of new bills of material and costs using the CAD database. It can be a very "smart" system which automates these functions or one that merely uses the company costing database and routing operations information. The degree of intelligence in the system determines if it is "generative" in that it automatically sets up the product routing or a "variant" system that seeks similar product routings for modification.

A link between business systems and the CAD system allows an interface with CAPP, as one bill of material is all that's needed, and no regeneration is required on the Manufacturing side of the business.

EDI (Electronic Data Interchange)

A nationwide link with suppliers and customers for electronic ordering, specifying, payment and a multitude of other needs. Electronic or "paperless", it ensures the fastest transmission of information and simplifies the paperwork mazes that we are familiar with today.

Summary

There are many other systems that can be added to any particular company's system. Such systems might include the automatic feedback of data from programmable controllers on automatic machines to give immediate feedback as to what is happening in any particular area. It can include the transmission of data from any point in the company back to a central point for analysis.

Central to any company's integration plans, however, must be "What are we trying to accomplish?" There are several points to be made in such integration planning but in summary, the following are those items which most companies are stating as their reasons for such integration.

- The design of products to better meet customer needs and quality expectations.
- The design of processes to ensure its consideration in the design.
- Reduction of design leadtime.
- High productivity through the release of producible designs.
- The use of common databases throughout a company to minimize errors and the duplication of effort in all functions.
- Better communications from companies to suppliers and customers.

Obviously, any company starting over today to design a totally integrated CIM system would do it differently. However, most companies have grown as previously stated through "islands of automation". These "islands of automation" must be allowed to communicate in order to gain efficiencies in productivity between the various systems. To do this can be very puzzling, but through a combination of available software and the use of in-house developed software, there is light at the end of the tunnel.

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A Relationship Between Exchangeable Sodium and Concretion Composition in Two Soils

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Abstract: One soil each of the Collins and Crowley series along the Castor River in southeastern Missouri was sampled to observe if exchangeable sodium influenced the elemental composition of concretions. In both soils Fe was highly partitioned into concretionary materials with no apparent segregation according to concretion size. Smaller concretions generally had smaller concentrations of Co and Mn with concretionary materials possessing most of the soil's Mn and Co. The elemental concentrations of Mn, Co, Ni and Cu increased dramatically in the Crowley's BCg horizon and this was coincident with a 2 pH unit increase to a neutral reaction. The composition of concretions may be used to assess the stability of boundaries if the boundaries represent a change in the soil environment sufficient to alter the concretions composition or form.

Key words: Concretions, manganese, cobalt, soil genesis

Introduction

Exchangeable sodium in soils having a udic moisture regime has been associated with feldspar weathering, a restricted drainage basin, irrigation waters with high SAR compositions and the local hydrology (Aide, 1987; Fehrenbacher *et al.*, 1963; Pettry *et al.*, 1981). In the southern Mississippi embayment and its attendant regions several investigations (Aide, 1987; Horn *et al.*, 1964; Pettry *et al.*, 1981; McQuaid *et al.*, 1987) have described soils with > 15% exchangeable Na at depths greater than those defined for natric horizons in Soil Taxonomy (Soil Survey Staff, 1975). Soil Survey Staff (1975) describes the natric horizon as "a special type of argillic horizon having either > 15% saturation with exchangeable Na in some subhorizon within 40 cm of the upper boundary or more exchangeable Na plus Mg than exchangeable Ca plus exchangeable acidity in some subhorizon within 40 cm of the upper boundary if the exchangeable Na content is > 15% within 2 m of the surface."

Preliminary sampling by the authors along the Castor River in southeastern Missouri revealed sufficient exchangeable sodium to qualify portions of these soils as natric horizons, except that these horizons occur > 40 cm below the top of the argillic horizon. Many of these soils exhibit a fluctuating water table and contain concretions between 2-10% of volume.

Concretions are soil features characterized as having either a different chemical composition or a fabric difference resulting in indurated grains of

various sizes, shapes, and colors. Gallaher *et al.* (1973a,b) investigated the chemical composition of concretions and observed entrained clays and a Mn-Ba core surrounded by an Fe-Ti enriched surface. Schwertmann and Fanning (1976) observed increasing Fe/Mn ratios upon progression from the concretion's core to its periphery. Smaller concretions had smaller Fe/Mn ratios. Several authors (Loganathan *et al.*, 1977; Traina and Doner, 1985) observed an abrupt Co sorption onto Mn oxides at $\text{pH} > 6$.

This study on selected soils along the Castor River in southeastern Missouri was initiated to test the hypothesis that the boundary between the acidic argillic horizon and the underlying sodium-enriched horizons has been in its present position for a long time. The focus of the investigation was the trace element composition of concretions. If the composition of concretionary materials alters abruptly and coincident with the transition of an acidic argillic horizon to an alkaline sodium enriched horizon, then the downward migration of the acidic argillic horizon is arrested or a lithologic discontinuity (change in parent material) exists. An inherent assumption is that the concretion's composition alters much more slowly than the downward migration of the acidic argillic horizon and that concretions are pedogenic and not depositional features.

Study Area

Two representative pedons in southeastern Missouri were selected by detailed mapping and numerous auger corings. Soil profiles were examined in excavated pits and were described and sampled using standard methods (Soil Survey Staff, 1984). Soils of the Collins and Crowley series were located (SW¹/₄ Sec. 30, T. 27N., R. 11E.) in Stoddard County, Missouri, on a floodplain and first terrace position of the Castor River, respectively. The Collins pedon (course-silty, mixed, acid, thermic Aquic Udifluvents) formed in moderately well drained silty alluvium, while the Crowley pedon (fine, montmorillonitic, thermic Typic Albaqualfs) formed in somewhat poorly drained silty and clayey alluvium. The contact between these soils is marked by a sharp rise of approximately 1 M. At the sampling location the Castor River is a 20 m wide, incised meandering river with a stream gradient < 0.3 m/km. Between 1900-1910 the Castor River was diverted by a diversion channel and stream flow is considerably reduced, thus soil drainage may be different than in the past.

Native vegetation was a hardwood forest consisting of sweetgum (*Liquidambar styraciflua* L.), whiten oak (*Quercus alba* L.), red oak (*Quercus falcata*), yellow poplar (*Liriodendron tulipifera* L.) and cypress (*Taxodium distichum* L.). Currently the Collins site is seeded to tall fescue (*Festuca arundinacea* Schreb), while the Crowley pedon is cropped with soybeans (*Glycine max* L. Merrill) and grain sorghum (*Sorghum bicolor* L. Moench). The climate is warm and moist with long summers and short winters. Mean monthly air temperatures range from 1°C in January to 27°C. Soil temperatures are in the thermic regime (15-22°C).

Laboratory

Samples were air-dried and sieved to remove coarse fragments ($> 2\text{mm}$). Particle size distribution was determined by sieving and centrifugal sedimenta-

tion with the whole clay fraction analyzed by x-ray diffraction (Jackson, 1965) with a Norelco Geiger counter spectrometer using Cu K radiation and a Ni filter. Mineral type and content were estimated from basal spacing and peak intensity.

Exchangeable Ca, Mg, K, Na, Mn, and Li extracted with neutral $N\text{NH}_4\text{OAc}$ were determined by atomic absorption/emission spectrophotometry (Chapman, 1965). KCl extractable Al was determined by reaction with aluminon (Peech, 1965). The effective cation exchange capacity (ECEC) was calculated as the sum of extractable bases and KCl exchangeable acidity. Exchangeable acidity was determined by titration. Soil pH was measured using equal volumes of water and soil.

Using air-dried soil samples concretions were separated by repeated dispersion. The remaining air-dried materials were sieved. Elemental extraction from concretions and from sieved soil was by (CDB) dithionite reduction (Mehra and Jackson, 1960). Iron, Mn, Cu, Co, Ni, and Li were analyzed by atomic absorption/emission spectrophotometry. All procedures were duplicated. A split soil sample was used for moisture determination.

Results

The Collins pedon (Table I) exhibits a silt loam Ap-C horizon sequence. The Ap horizon is characterized as having a moderate very fine granular structure with an abundant root mass. The C2 horizon displays weak medium subangular blocky structures with a few fine prominent light gray (10YR 7/2) mottles. The C3-C4 horizons are massive horizons with common to many, fine to medium prominent light gray (10YR 7/2) mottles and the massive C5 horizon exhibits many medium prominent dark yellowish-brown (10YR 4/4) mottles. Visual evidence of concretions coincides with the appearance of mottling with the highest expression occurring in the C5 horizon.

The Crowley soil exhibits an Ap-E-Btg-BCg horizon sequence. The silt loam textures in the Ap-E horizons abruptly change to silty clay textures in the argillic horizons. Common, coarse, prominent, strong-brown (7.5YR 5/8) mottles at 23 cm gradually convert to a few, fine, prominent, yellowish-brown (10YR 5/6) mottles at 120 cm, thereafter abruptly converting to many fine prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles. At sampling, the argillic horizon had a hard consistence (dry) while the BCg horizon exhibited a firm consistence (moist). Concretions are common in all horizons, especially the BCg horizon. Concretions from the Crowley pedon require considerable finger pressure for crushing; whereas, those from the Collins pedon are fragile.

The effective cation exchange capacity (ECEC) for the very strongly acid Collins pedon is low, relatively constant throughout its profile and shows increasing concentrations of exchangeable aluminum at increasingly greater depths. The silt loam Ap horizon of the strongly acid Crowley pedon has a low ECEC; while the ECEC's of the silty clay argillic horizons are high. Exchangeable Mg and Na increase with soil depth, especially in the Btg3 and BCg horizons.

The clay mineralogy of the Ap horizon of the Crowley pedon is quite similar to that of the Collins Ap horizon in that vermiculite, clay-mica, and kaolinite are the dominant clay minerals. The Btg horizons of the Crowley pedon are essentially smectitic with minor quantities of clay-micas and kaolinite, while the C horizons of the Collins pedon contain a mixed mineralogy.

Table I. Selected morphological, physical and chemical properties.

Horizon	Depth CM	Color	Sand	Silt %	Clay	pH	Ca	Mg	Exchangeable		Al	H	
									K	Na			
										cmol _c kg ⁻¹			
<i>Collins</i>													
Ap	0-18	10YR 5/3	0	86	14	4.7	3.2	1.6	0.2	0.2	0.0	0.2	
C1	18-38	10YR 4/3	0	87	13	5.0	3.0	1.4	0.2	0.2	0.0	0.2	
C2	38-61	10YR 4/4	1	84	15	4.7	1.8	1.3	0.2	0.3	1.5	0.5	
C3	61-84	10YR 4/4	3	78	19	4.6	1.4	1.7	0.2	0.3	2.7	0.5	
C4	84-122	10YR 4/4	2	74	24	4.5	1.3	1.9	0.2	0.3	2.7	0.5	
C5	122-152	10YR 7/2	5	79	16	4.4	1.3	1.5	0.2	0.4	2.5	0.3	
<i>Crowley</i>													
AP	0-10	10YR 4/2	10	80	10	5.4	1.5	1.2	0.3	0.3	0.0	0.7	
E	10-23	10YR 7/1	11	85	4	5.5	1.1	0.9	0.2	0.3	0.0	0.7	
Bt _g 1	23-38	2.5YR 7/2	4	60	36	5.4	2.4	6.3	0.3	1.5	3.6	1.0	
Bt _g 1	38-51	2.5YR 7/2	2	60	38	5.2	2.3	6.1	0.3	1.6	2.6	2.2	
Bt _g 2	51-79	2.5YR 6/2	4	52	44	5.2	2.3	10.3	0.4	1.7	2.1	1.6	
Bt _g 2	79-104	2.5YR 6/2	7	42	51	5.1	2.9	15.3	0.5	6.6	1.2	1.0	
Bt _g 3	104-125	2.5YR 5/2	3	59	38	4.9	2.3	16.9	0.4	6.3	0.9	0.4	
BC _g	125-152	2.5YR 6/2	8	56	36	6.9	4.4	17.4	0.4	8.1	0.0	0	

The elemental composition of concretions (Table II) is a function of soil type, concretion size and profile depth. Iron is more abundant in the Crowley pedon and does not selectively partition according to concretion size. On a unit mass basis larger concretions contain greater concentrations of Mn and Co. Concretion concentrations of Mn, Co, Ni, and Cu from the Crowley's BCg horizon are dramatically higher than for other soil horizons. Coincident with this compositional change is a 2 pH unit increase to a neutral reaction. Lithium was not detected, thus the Mn mineral Lithiophorite is not likely present (McKenzie, 1977).

Regression analysis of Mn concentrations in concretionary materials with Co as the dependent variable demonstrated that Mn and Co are significantly associated ($r=0.91$). Soil type, soil depth and concretion size did not affect the

Table II. Elemental analysis of concretions and concretion-free soil

Horizon	Size	Concretions CDB***					Soils**		% Total metal in concretions	
		Fe	Mn	Co	Ni	Cu	Fe	Mn	Fe	Mn
<i>Collins</i>										
C3	1	6250	4250	125	8	18	4510	1440	3.8	6.2
	2	7290	3460	90	8	18				
	3	7290	2660	55	8	14				
C5	1	5560	3320	100	8	11	4810	2180	3.0	2.9
	2	5560	3060	70	8	11				
	3	4510	1595	35	8	11				
<i>Crowley</i>										
Ap	1	13190	4920	55	8	14	1950	2010	34.5	14.8
	2	5900	1460	35	8	11				
	3	7290	1990	70	8	11				
Btg ¹	1	20830	8050	63	8	11	5360	228	20.4	34.5
	2	22220	1990	55	8	11				
	3	18050	1330	45	8	11				
Btg ²	1	20140	4520	70	8	11	1990	57	28.6	64.7
	2	25000	2130	55	8	7				
	3	20830	1460	45	8	11				
Btg ³	1	21140	3320	63	8	11	3580	214	15.1	19.8
	2	22220	1590	55	8	11				
	3	25000	1330	45	8	11				
BCG	1	9370	19150	315	205	50	5680	567	12.7	66.8
	2	7640	15960	250	170	36				
	3	14580	13830	135	135	50				

1 = >1mm, 2 = 1-0.5mm, 3 = 0.5-0.1mm

** CDB extraction sieved to remove masses > 0.1mm

*** CDB = citrate-bicarbonate-dithionite extraction

correlation, thus Mn and Co are likely transported and deposited into concretionary masses by a mechanism ensuring the high correspondence. The preferred adsorption of Co onto Mn oxides as proposed by Traina and Doner (1985) may be such a mechanism.

Approximately 4% of the mass in the Collins C2-C5 horizons is composed of concretions with approximately 4% of the total Fe and Mn and nearly 100% of the total Co partitioned into these concretions. Approximately 2-10% of the Crowley's mass is composed of concretions which contain 35-13% of the total Fe, 15-67% of the total Mn and nearly 100% of the total Co. Nickel and copper are also associated with concretions.

Discussion

The Collins pedon does not contain an argillic horizon or appreciable levels of exchangeable sodium. The Crowley pedon contains a strongly acidic argillic horizon with significant levels of exchangeable sodium at 53 cm below the argillic horizon's upper boundary. The BCg horizon abruptly differs from the overlying argillic horizon by having a neutral reaction and concretions having significantly greater concentrations of Mn, Co, Ni and Cu.

Originally Co, Fe, and Mn may be considered as being randomly dispersed throughout the soil and pedogenic processes concentrated these elements into concretions. Current thinking envisions a fluctuating water table and rapidly alternating episodes of oxidation-reduction as necessary conditions for concretion formation (Schwertmann and Fanning, 1964; Marshall, 1977). Cobalt transport to the BCg horizon from either the overlying argillic horizon or from subsurface lateral flow would require a considerable time interval and a nonalkaline profile. Progressive weathering may result in sodium removal and the initiation of an acid argillic horizon. Given that an acidic argillic horizon overlies a neutral BCg horizon, then any Co ions leached by percolating waters would undergo a preferred adsorption onto concretion surfaces after a mechanism proposed by Loganathan *et al.* (1977) or Traina and Doner (1985). Given the presumed long time period necessary for Co migration coupled with the large variations in the composition of the concretions between the Btg3 and BCg horizons, the boundary between these horizons must be quite stable.

Currently 18 soils are being examined to test a hypothesis that concretion composition is a result of pedogenic processes and not deposition.

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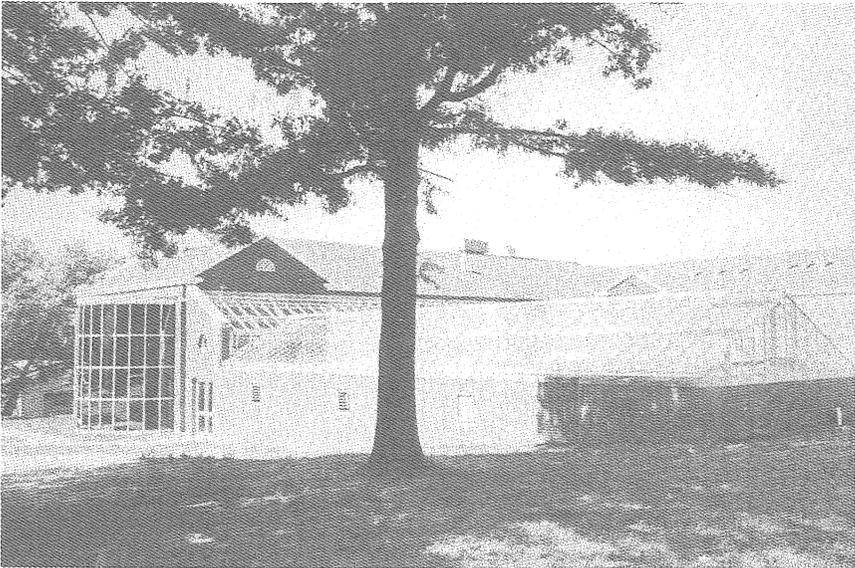
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Tabor, R. L. and Terry, D. E., Department of Agriculture, Central Missouri State University, Warrensburg, MO 64093. IRRADIATED TOMATOES: CUSTOMERS' ATTITUDE AND ACCEPTANCE. An urban (Kansas City), suburban (Blue Springs) and rural area (Warrensburg) were surveyed. The first questions were constructed in such a way as to compare the consumers' willingness to purchase irradiated tomatoes versus nonirradiated tomatoes when the individual was shown only the unexplained irradiation logo. At equal prices results indicated that 29% preferred tomatoes with the irradiated symbol, 15% did not and 56% were indifferent. In the second stage of questioning the logo was identified. The term "irradiated" caused a substantial decrease in customer demand for the irradiated tomatoes. Prior to the final stage of questioning, explanations of irradiation and safety studies associated with the process were presented to each consumer. This additional information resulted in a dramatic increase in consumer acceptance. Even at a \$.03 higher price per pound for irradiated tomatoes, consumer willingness to buy was 48% as compared to only 46% for the lower priced nonirradiated produce. Support: CMSU Faculty Research Grant.

Ford, D. M., Division of Science, Northeast Missouri State University, Kirksville, MO 63501. PHOTOPERIOD EFFECTS ON LEAF SENESCENCE IN SOYBEAN. In soybean [*Glycine max* (L.) Merr.], leaf and canopy photosynthetic rates decline during the seedfilling period because of monocarpic leaf senescence. This likely limits seed yield. Monocarpic leaf senescence is a developmental process known to be influenced by daylength. To study this influence the photoperiod experienced by field-grown soybean plants (cv. 'Amsoy') was altered. Incandescent lights illuminated selected plots for 3 to 4 hours each night beginning 7, 18, 29 July, 8, or 23 August. Flowering began on 21 June and seedfilling on 30 July. CO₂-exchange rate, chlorophyll content, and protein content of recently-expanded leaves were measured to determine the timing and rate of leaf senescence. Dry masses per plant of stems, leaves, and fruits were determined. Light treatments had no effect on total dry mass per plant or on initiation of leaf senescence. Treatments begun on or after 29 July had no effect on leaf or plant development. Treatments begun before 29 July slowed the rates of leaf senescence and fruit development. Support: NMSU Faculty Research Grant.

Johnson, G. D., McVay, R. G., Kulak, P. A., and Shatswell, K. W., Department of Agriculture at Missouri Western State College, St. Joseph, MO 64507. DWARF VARIETIES OF SOYBEANS VS. FULL SEASON VARIETIES OF SOYBEANS. The dwarf varieties of Hobbitt and Elf were compared to the full season varieties of Pioneer 3981 and Williams 82. Data was gathered over a period of three years concerning yield, insect and disease resistance, and lodging. Fertilizer, lime and the other inputs were applied at the same rate over the entire field. Three replications were used each year. Yield data was collected and analyzed over a three year period of time, using a "One Way Analysis of Variance With Multiple Entries" type of statistical analysis. There were no significant differences between the dwarf soybean and the full season soybeans. The full season beans had an average yield of 44.65 bushels per acre whereas the dwarf varieties had an average yield of 46.07 bushels per acre. These results may be of considerable interest to the area farmers, since the smaller plants (dwarfs) do not require as much moisture and nutrients as the larger (full season) plants.

McCairel, M. H., Carrel, J. E., and Slagle, A. J., Division of Biological Sciences; **Doom, J. P., Brill, J., and McCormick, J. P.,** Department of Chemistry, University of Missouri-Columbia, Columbia, MO 65211. SEXUAL DIFFERENCES IN CANTHARIDIN PRODUCTION AFTER BLISTER BEETLES REACH ADULTHOOD. Experiments were designed to test the hypothesis that cantharidin production is amplified in adult male blister beetles whereas it is inhibited in adult females. We used all larval, pupal, and adult instars of *Epicauta pestifera*, a species having hypermetamorphic development typical of the Meloidae. We quantitatively determined cantharidin in laboratory reared beetles using capillary gas chromatography. Cantharidin in larvae generally increased from a few micrograms to 118 ug/individual as they fed and grew, but it did not change significantly after larvae ceased feeding even though they progressed through diapause, two additional larval molts, and a pupal molt. Furthermore, juveniles exhibited no significant difference in cantharidin between the sexes. Cantharidin in adult males increased rapidly whereas it decreased steadily in adult females, confirming our hypothesis. Supported by NIH grants AM31186 and RR07053.

Bushmeyer, W. W., VanCleave, H. B., Ewing, D., and Thompson, L., Department of Agriculture, Central Missouri State University, Warrensburg, MO 64093. HERBICIDE EFFICACY TRIALS ON SOYBEANS. This study was done to determine effects of eleven single and prepack/combinations herbicide on soybean roots, stems and leaves, annual grasses and broadleaf weeds plus the herbicide cost per acre. Twelve plots 15' x 100' with two replications were used as treatment plots along with two untreated control plots. Soybeans were established using conventional tillage and planting and a field cultivator was used for chemical incorporation. Four common grasses were broadcast and incorporated along with the chemicals, final field preparation and planting was completed May 14, 1987. All plots were harvested October 1, 1987. Soybean roots were not significantly damaged and stems and leaves were slightly injured. The lowest yields were from the untreated plots where 28.3 bushels per acre were

harvested. The highest yield was 40.2 bushels per acre using Sonalac at .94#/A. The most expensive treatment was Lasso & Scepter at \$20.94 per acre. The least expensive was Treflan at \$4.78 per acre.

Terry, D. E. and Lichtenthaler, A. B., Department of Agriculture at Central Missouri State University, Warrensburg, MO 64093. OCCUPATIONAL CHOICES OF MISSOURI'S NON-LAND GRANT AGRICULTURAL STUDENTS. This study examines background characteristics and occupational choices of agricultural students in Missouri's non-land grant universities. Surveys of Missouri's freshman and senior agricultural classes, at five state supported institutions offering four-year degrees in the basic agricultural sciences, were conducted in the Spring of 1987. While 86.1% of the students lived on farms, only 55.2% enrolled in vocational agriculture courses in high school. Over 30% of all students indicated their major to be Agribusiness, while 21.9% and 10.2% were majoring in Animal Science and Agricultural Economics, respectively. Most popular among occupational choices was farming, with 49.4% of all students identifying this career as "very" or "extremely" interesting. Managing an agribusiness was second, with similar responses from 39.2% of those surveyed. Twenty-six percent of the freshman expected to farm after graduation, while only 15.1% of the seniors saw this as a viable alternative. Support: CMSU Faculty Research Grant.

Biology

Priesendorf, T. and Castaner, D., Biology Department, Central Missouri State University, Warrensburg, MO 64093. *LEONURUS MARRUBIASTRUM* L. (LAMIACEAE), AN ADDITION TO THE FLORA OF MISSOURI. Biennial-motherwort was collected for the first time in Missouri during the summer of 1987 at the Jamerson McCormack Wildlife Refuge Area in Holt County. Two collections were made: each differed only slightly from the typical description. Biennial-motherwort is a native to northern Asia and Europe from the Balkans to central Europe. It is one of the numerous European invaders to the eastern United States in eastern Pennsylvania and West Virginia. In the central U.S., it is found in northeast Kansas, and along the Missouri in central and southern Nebraska and Iowa. It should now be expected along the Missouri River counties in Missouri from Iowa to Kansas City.

Carlson, J. R. and Ratliff, C. R., Cleveland Chiropractic College, 6401 Rockhill Road, Kansas City, MO 64131. THE ROLES OF ABDOMINAL MOTOR NEURONS IN THE ECDYSIS OF THE AUSTRALIAN FIELD CRICKET, *TELEOGRYLLUS OCEANICUS*. Ecdysterone, the insect molting hormone, has been implicated in modulating the availability of abdominal peristaltic waves during the ecdysis (molting) of the cricket. Electromyographic recordings from eight abdominal muscles showed that each was controlled by two or three motor neurons which generated short bursts during peristaltic waves. These fired tonically to produce a continuous dorsoventral compression of the abdomen. Compression began during ecdysis and lasted for 24 additional hours. Since wing expansion was completed by one hour after ecdysis, this continuation of dorsoventral compression is quite unexpected and may indicate burscion involvement in neural control of sclerotization related behavior.

Rouse, A. M. and Babrakzai, N., Biology Department, Central Missouri State University, Warrensburg, MO 64093. ANTIMITOTIC AND MUTAGENIC EFFECTS OF THE HERBICIDE TREFLAN ON GROWING ONION ROOT TIPS. Growing onion root tips were subjected for 24 hours to six different concentrations of Treflan, ranging from 0 to 10,000 ppm. They were fixed at the same time and studied cytologically. The mitotic indices (MI) of Treflan treated root tips were significantly lower (0.78, 0.33, 0.27, 0.15, 0.06, 0.04) than controls (6.2). These data indicate a log to log relationship between decreasing doses of Treflan and corresponding decrease in MI. Observed chromosomal mutations in all treated systems included (1) fuzzy chromosomes, (2) polyploidy, (3) anaphase bridges, (4) multipolar spindles, (5) c-metaphases and (6) anaphase arrests. From this preliminary study it is concluded that the minimum effective dose of Treflan is much lower than 0.1 ppm. The possibility of its mutagenic potential in sub-optimal doses, e.g. ppb or ppt in the environment or laboratory conditions remains to be explored. Supported in part by a CMSU Research/Technology small business grant 02-BMA06.

Gilbertson, R. E. and Babrakzai, N., Central Missouri State University, Warrensburg, MO 64093-5053. OBSERVATIONS ON THE KARYOTYPE OF *ANGUISPIRA ALTERNATA* (GASTROPODA: PULMONATA). Three populations of *A. alternata* (two from Missouri and one from Rhode Island) were studied cytologically. Based on a study of 25 karyotypes, a diploid number of 64 chromosomes was determined for this species. There are 21 metacentric, 7 submetacentric and 4 subtelocentric chromosomes in the karyotypes of the Rhode Island and Warrensburg, Missouri populations. The karyotype of the Pleasant Hill, Missouri, population consisted of 20 metacentric, 5 submetacentric and 7 subtelocentric chromosomes. This observed variation is hypothesized to be due to pericentric inversions and/or translocations in the Pleasant Hill population, thus indicating karyotype evolution and potential speciation. The karyotype of the three groups has one pair of chromosomes with nucleolar organizer regions (NOR's). Heterozygosity of the NOR was observed in all populations.

Goomer, R. S., Gathman, A. C., and Lilly, W. W., Biology Department, Southeast Missouri State University, Cape Girardeau, MO 63701. THE ISOLATION, PURIFICATION AND DENATURATION/RENATURATION CURVE ANALYSIS OF *CUPHEA* DNA. DNA was isolated from *Cuphea ilauea* leaves by repeated phenol/isoamyl alcohol:chloroform (IAC) extractions and purified via hydroxyapatite chromatography with urea phosphate (UP-HA). The UP-HA technique for *Cuphea* is compared with two other DNA purification techniques. Melting curve of the purified DNA was determined in a Perkin-Elmer spectrophotometer equipped with a thermal flow cell.

The melted DNA was reassociated by incubation at 60°C. A Cot curve, where Co is the initial DNA concentration and t is the time of incubation, was determined. The purified DNA showed a strong absorbance peak at 260nm with A260 to A280 ratio close to 2. The melting temperature (Tm) of *Cuphea* was determined to be 89.5°C. The Cot curve indicates at least two species of repetitive DNA (repDNA). One of the repDNA species reassociated between Cot values of 0.1 and 0.5 and the second between 0.7 and 3.0.

May, R. and Gathman, A. C., Biology Department, Southeast Missouri State University, Cape Girardeau, MO 63701; **Thompson, A. E.**, USDA Agriculture Research Service, Phoenix, AZ; **Ray, D. T.**, University of Arizona, Tucson, AZ. MEIOTIC ANALYSIS OF HYBRIDS COMPARED WITH MORPHOLOGICAL CLASSIFICATION IN THE GENUS *CUPHEA* (LYTHRACEAE). The plant genus *Cuphea* is under development as a new cultivated source of lauric acid, a component of soaps and detergents. Plant breeders working on domestication of these plants require accurate information on the relationships among species. In this study we estimated DNA similarity between species by looking at meiotic chromosome pairing in interspecific hybrids. In some instances, meiotic affinity data fail to support a previous classification of the species based on morphological similarity. This suggests that some morphological changes used in classification may result from changes in one or a few genes. Supported in part by Southeast Missouri State University Grants and Research Funding Committee.

Faber-Langendoen, D. and Dina, S. J., Department of Biology, St. Louis University, St. Louis, MO 63103. THE ROLE OF FLOODING AND LIGHT ON THE GROWTH OF *CEPHALANTHUS OCCIDENTALIS* L. (BUTTONBUSH). Two studies are presented. In the first study, ten natural forest ponds were sampled in southern Ontario to determine the abundance of *Cephalanthus* in four zones (forest edge, mound, platform and emergent) in increasing levels of flooding. *Cephalanthus* was restricted primarily to the latter two zones. Analysis of soil, water and light factors between ponds showed abundance to be most significantly correlated with water depth. In the second study, growth response of seedlings to light was tested in Missouri. Greenhouse response under drained conditions showed growth was greatest at highest light levels but still evident at lowest levels; no mortality occurred at any light level used. Field response under flooded conditions showed *Cephalanthus* had a high tolerance to flooding, but no correlation of growth to light was found. Thus, *Cephalanthus* may be a light-flexible species. Flooding plays a primary role in determining the distribution and abundance of *Cephalanthus*.

Ashley, D. C. and Butner, C. H., III, Biology Department, Missouri Western State College, St. Joseph, MO 64507; **Carpenter, Jack**, Public Health Department, St. Joseph, MO 64507. PRELIMINARY SURVEY FOR HEARTWORM IN DOGS FROM THE ST. JOSEPH ANIMAL SHELTER. Heartworms (*Dirofilaria immitis*) are parasites of veterinary and medical importance and information is needed concerning their distribution and abundance throughout the United States. We have been examining wild animals (primarily coyotes and foxes) since 1986. Dogs euthanized at the St. Joseph Animal Shelter as part of the city's animal control program were examined for heartworms. To date, 83 dogs have been examined for the presence of worms in the heart and lungs. Ten (12%) of these animals were infected with *D. immitis*. None of 35 animals younger than six months was infected. Ten (24%) of 41 animals older than 8 months were infected. From one to nine worms (mean, 3.5; std. dev., 3.3) were found in infected hearts.

Stefan, S. J. and Millikan, D. F., Department of Plant Pathology, University of Missouri-Columbia, Columbia, MO 65211. AN UPDATE ON *IN VITRO* CULTURE OF BLACK WALNUT, *JUGLANS NIGRA* L. Successful establishment, proliferation and multiplication of mature black walnut, *Juglans nigra* L., and the grafting of culture shoots onto seedling rootstocks, have been previously reported. Three cuttings taken from grafted culture shoots produced a few roots when dipped in 0.1% IBA powder prior to being stuck in the mist chamber. Others developed callus which possessed the potential to initiate roots after the cessation of dormancy. Investigations on *in vitro* rooting also have been continued. Treatments to overcome seasonal dormancy of the cultures, which limits the number of elongating shoots, are being tested. The increase of calcium and magnesium salts, addition of adenine sulfate (80 mg/l), deletion of cytokinins, cold shock and dark treatment, which have produced shoots in other species, have thus far been ineffective for black walnut.

Warmund, M., Stefan, S., Millikan, D. F. and George, M. L., Departments of Horticulture, Plant Pathology, and School of Forestry, Fisheries, & Wildlife, University of Missouri-Columbia, Columbia, MO 65211. FRUIT QUALITY, FLOWER BUD AND WOOD HARDINESS OF SOME LOW TEMPERATURE RESISTANT PEACHES. Enhanced resistance in the flower buds to low and fluctuating temperatures could lessen crop failures in years of adverse temperatures. Similarly, enhanced resistance in the wood would reduce the incidence of pathogen induced cankers. Earlier we reported that low temperature resistance occurs in some seedling clones from northwest China, and this could be transferred to the F₁ and F₂ generations of seedlings from controlled crosses. In 1987, several different hardy peach clones and their hybrids fruited and were evaluated. Fruit of two of the hybrid seedlings possessed the size and quality approaching that of commercial cultivars. When seven of these clones and a cultivar, Reliance, were exposed to -30C only the Chinese clone, N-10, had a good flower bud survival and was free from wood injury. Low temperature in the flower buds and wood of peach appears to be independently inherited, but that of wood is the more complex.

Sullins, T., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. GRAIN SIZE ANALYSIS OF INTERIOR LEAST TERN NESTING SUBSTRATE. During the 1987 nesting season, 128 substrate samples were collected from 4 separate Interior Least Tern nesting sites on Mississippi River sandbars and islands. Three of the sites had active breeding colonies during 1987. The other had been used in 1986, but not in 1987. Samples from the 3 active colonies were taken from the nest scrape upon abandonment (or within 1 m if the

nest was still active). The samples from the unused site were collected along line transects in the area most often used by nesting terns. Each sample was sifted and separated into 3 component parts: silt, sand, and gravel. Analysis of samples taken from the 3 active colony sites revealed a wide variation in the proportions of sand (32.96-99.44%) and gravel (0-66%), but were fairly constant in silt content (0-0.127%). The unused site showed little variation in grain size with sand the dominant component (88 + %). Comparisons of known microhabitat demands of tern egg incubation and the microhabitat types produced by areas of certain soil composition should provide useful insight in determining the usefulness of the data. Equipment was provided by the Missouri Department of Conservation.

Crooks, J.R. and Sells, G. D., Science Division, Northeast Missouri State University, Kirksville, MO 63501; **Mock, O. B.**, Kirksville College of Osteopathic Medicine, Kirksville, MO 63501. EFFECTS OF AGING ON OXIDATION OF PROLINE BY MITOCHONDRIA ISOLATED FROM LIVER AND BRAIN OF SHREWS (*CRYPTOTIS PARVA*). The effects of aging on mitochondrial function were studied by removing brain and liver mitochondria from male shrews of three age classes (50, 180 and 360 days). Samples from six shrews were pooled to obtain sufficient amounts to study oxidation of succinate, proline and glutamate + malate (G+M). Mitochondria isolated from liver oxidized succinate at State III rates of 75, 74 and 123 nmoles of oxygen $\text{min}^{-1} \text{mg}^{-1}$ protein for shrews of increasing age. A similar pattern was observed for oxidation of G+M and proline with increasing age. However, mitochondria isolated from brain tissue oxidized proline at decreasing rates (20, 11 and 6 nmoles oxygen $\text{min}^{-1} \text{mg}^{-1}$ protein, respectively). Since brain mitochondria from aging shrews oxidize proline at decreasing rates when compared 1) to other substrates and 2) to the ability of liver mitochondria to oxidize proline, brain cells may be affected differentially with age and a control mechanism may exist which allows greater conservation of amino acids in brain with increasing age.

Bernhardt, P., Biology Department, St. Louis University, St. Louis, MO. PULSES OF POLLINATION SYNDROME IN THE AUSTRALIAN ORCHIDS. The pollination biology of the terrestrial Orchidaceae of temperate Australia is divided into three sequentially overlapping syndromes correlated to the emergence of insects. First, the orchid genera flowering from mid-winter to early spring (July-September) are pollinated almost exclusively by microdpterans/microphilids with orchid flowers offering nectar, sexual mimics or brood-site deception. The second syndrome occurs from early spring until early autumn but peaks in October and is typified by food and sexual mimicry exploiting winged Hymenoptera by food and/or sexual mimicry. The final syndrome begins in mid-Spring and ends by mid-summer with orchid flowers offering nectar in shallow/short cups for generalist foragers including megadpterans and small hymenopterans including worker ants. Although the phenology of pollination syndromes remains temporally clustered it does not reflect the phylogeny of endemic orchids.

Aldridge, R. D., Department of Biology, St. Louis University, St. Louis, MO 63103. THE MALE REPRODUCTIVE BIOLOGY OF THE ROUGH GREEN SNAKE (*Opheodrys aestivus*). The green snake exhibits post-nuptial spermatogenesis. The testis is quiescent in the spring and peaks both in size and spermatogenic activity in July and August. The sexual segment of the kidney exhibits a cycle of activity opposite from that of the testis. In the sex segment the peak of size and secretory activity occurs in the spring and fall with the nadir occurring in June and July. The plasma testosterone levels parallel the sex segment activity.

Bio-Medical

Lockhart, M. L., Science Division, Northeast Missouri State University, Kirksville, MO 63501; **Rinaldy, A.**, Department of Biochemistry, Vanderbilt University, Nashville, TN 37232; **Feunteun, J.**, Laboratoire d'Oncologie Molec., Inst. Gustave Roussy, Villejuif, France; **Rosenberg, B. H.**, Sloan-Kettering Institute for Cancer Research, Walker Lab., Rye, NY 10580. NON-ESSENTIAL DNA SEQUENCES IN THE SV40 GENOME THAT ENHANCE THE RATE OF DNA REPLICATION WHEN IN THE CIS CONFIGURATION. Two sites in the SV40 genome, mapping at .56 and .21, each consisting of fewer than 10 base pairs, are shown to have a cis-effect of the same magnitude on the rate of DNA replication. Deletion of both of these sequences has the same effect as deletion of either one. Neither of these sites has unequivocally been shown to have a trans-function. Deletions at .91 and .73 on the map do not exert a cis-effect on the rate of replication; although non-essential, these sites do possess meaningful trans-functions. An addition at .17 is also without effect. The evidence suggests that the cis-acting sequences play an active role in enhancing replication, perhaps functioning together to induce a preferred configuration. There may be other, unidentified sites that can perform essentially the same function. Supported by the NCI (NCI-08748-16), DOE (79EV10263), and EPA (R809550).

Jay, A. E. and Loewenstein, K., Division of Science, Northeast Missouri State University, Kirksville, MO 63501. EFFECT OF FOLIC ACID ON RAT INTESTINE SMOOTH MUSCLE RELAXATION. Smooth muscle relaxation is mediated by 3', 5'-cyclic guanosine monophosphate (cGMP), and folic acid significantly increases cGMP levels in a variety of rat tissues. Therefore, a study was conducted to measure the effect of a 10 nmol perfusate of folic acid on rat intestinal smooth muscle relaxation. Isolated jejunal segments six cm in length were sectioned into helical strips, secured in a perfusion chamber, and perfused over a 30 minute period with the perfusate minus folic acid (control) or with folic acid (treatment). An initial tension of $1.107 \times 10^{-2} \text{n}$ was placed on the suspended intestinal strips, and physiograph recording of tension loss was made. Final mean tension loss, expressed in newtons, for control segments was $0.3986 \times 10^{-2} \text{n}$ whereas for treatment segments it was $0.8859 \times 10^{-2} \text{n}$. Statistical analysis of

these data indicated that folic acid at the concentration used significantly ($P < 0.05$) decreased rat jejunal smooth muscle tension.

Zond, A. G. and Jay, A. E., Division of Science, Northeast Missouri State University, Kirksville, MO 63501. EFFECT OF PANTOTHENIC ACID ON 3', 5'-CYCLIC GUANOSINE MONOPHOSPHATE LEVELS IN RAT AORTAE. Radioimmunoassays of 3', 5'-cyclic guanosine monophosphate (cGMP) levels in transversely excised segments of rat aortae incubated in the presence (treatment) or absence (control) of pantothenic acid were performed. Millimolar concentrations of pantothenic acid studied were: 0.0, 0.01, 1.0, and 100.0. Mean levels of cGMP according to treatment, expressed as picograms per microgram protein, were: 0.01770 ± 0.006 , 0.02705 ± 0.012 , 0.03310 ± 0.009 , and 0.05050 ± 0.019 . A plot of these data suggested a concentration-dependent response. However, only the 100.0 mM concentration of pantothenic acid produced a response which was significantly ($P < 0.05$) above control values. The reaction was not saturable at the concentrations of pantothenic acid studied, but may be at higher concentrations. These results are in agreement with those reported on the effects of pantothenic acid on cGMP levels in other organs and tissues of the rat.

Niwano, Y., Mitra, R., Caldwell, C. W., Abdalla, E. B., Becker, B. A., and Johnson, H. D., Department of Dairy Science and Pathology, University of Missouri-Columbia, Columbia, MO 65211. FURTHER STUDY OF IMMUNOSUPPRESSION IN HEAT-STRESSED EWES. PRESENCE OF IMMUNOSUPPRESSIVE FACTOR(S) IN SERUM FROM HEAT-STRESSED EWES? Our previous studies have shown the suppression of mitogen-induced proliferative response of peripheral blood mononuclear cells (PBMN) of heat-stressed ewes. This study was conducted to elucidate the mechanism by which heat stress causes immunosuppression in ewes. Supplementation of serum from heat-stressed animals suppressed significantly the response of PBMN from healthy ovine, bovine and human donors. No difference was observed in the viable cell recovery when PBMN from a healthy ovine donor were incubated with serum from the two groups in the absence of mitogen. There were no significant differences in serum concentrations of total protein, albumin and cortisol. Serum soluble class II antigen, however, showed higher level in heat-stressed animals. These results suggest that the immunosuppression observed in heat-stressed ewes could be in part mediated by serum factor(s) and this factor(s) could induce suppressed T-cell function in a species non-specific manner.

Westhoff, R. and Theobald, R., NMSU and KCOM, Kirksville, MO 63501. FELINE BLADDER RESPONSE AFTER GONADECTOMY. We previously reported sex based differences in bladder smooth muscle responses showing that bladder smooth muscle in male cats was more responsive to inhibitory stimuli than that in female cats. Pretreatment of cats with a gonadotropin releasing hormone antagonist ([Ac-2-D-Nal¹, 4-C1-D-Phe², 3-D-Pal³, D-Arg⁶, Trp⁷, D-Ala¹⁰] GnRH, 2.5 mg/kg/day) for two days selectively increased tissue responsiveness to P₂ receptor agonists, such as ATP. Current experiments studied the effects of gonadectomy, 30 days prior to use in an acute experiment. Naive cats were castrated or ovariectomized, used in an acute experiment which determined responsiveness of bladder smooth muscle to various stimuli. Data from these experiments show that the effect of gonadectomy is different than the effects of inhibition of gonadotropin releasing hormone. Gonadectomy generally decreased the responsiveness of the bladder smooth muscle to P₂ receptor agonists. In fact, gonadectomy consistently decreased the responsiveness of the bladder to all stimuli that were tested. This study strengthens the evidence indicating that sex hormones have some role in modulation of bladder smooth muscle response.

Cheng, J. W. and Brooks, C. S., Department of Medicine, University of Missouri Health Science Center and Harry S. Truman Memorial Veterans Hospital, Columbia, MO 65212. ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS): THE CRITICAL IMPORTANCE OF DETERMINING OXYGEN DELIVERY. The acute respiratory distress syndrome (ARDS) is seen in association with a variety of severe illnesses, and mortality may result in 50% of cases. A critical element to management of this syndrome is maintenance of oxygen delivery to tissues. Calculating tissue oxygen delivery, as opposed to simply measuring plasma oxygen concentration, is mandatory in the management of ARDS. This case report reviews the causes and pathophysiology of ARDS and illustrates the necessity and method for making this critical determination. Key Index Terms: Acute respiratory distress syndrome (ARDS), Positive End Expiratory Pressure (PEEP), systemic oxygen transport, alveolar-arterial oxygen gradient.

Wagnon, R. J., Sandefur, R. M., and Ratliff, C. R. with technical assistance from **Burke, J. M. and Vella, S.,** Research Department, Cleveland Chiropractic College, Kansas City, MO 64131. THE APPLICATION OF CHIROPRACTIC ADJUSTMENT TO THE TREATMENT OF HYPERTENSION. Early work from this laboratory identified three spinal levels associated with volume-dependent hypertension. A crossover study was undertaken to ascertain the effect of chiropractic adjustment of these lesions on serum aldosterone levels in hypertensive patients. Laragh and others have shown a relation between the renin-aldosterone axis and hypertension. The criteria for patient selection were based upon those of Laragh for low renin-high aldosterone level hypertensive patients. All results were subjected to analysis of variance. The hypertensive patients underwent a significant decrease in serum aldosterone levels after therapy. Blood pressure alterations were not significant during the study.

Garris, D. R., Department of Anatomy, Cleveland Chiropractic College Research Laboratory, Kansas City, MO 64131. HISTOLOGICAL AND MORPHOMETRIC ANALYSIS OF UTERO-OVARIAN ADIPOSITY AND ATROPHY IN GENETICALLY DIABETIC MICE. The effect of progressive, diabetes-associated adiposity on reproductive tract structure and function was examined in 4- to 16-week-old C575BL/K_J, control (+/?) and diabetic (db/db) mice. Uterine and ovarian tissues were analyzed by transmission electron microscopy for ultra-structural changes associated with increased intracellular lipid accumulation. In addition, the same tissues were analyzed for

changes in activity of tissue lipoprotein lipase, an enzyme that hydrolyzes lipoprotein-associated triacylglycerols and supports the cellular uptake and storage of free fatty acids. Between 8 and 16 weeks of age, intracellular lipid deposits increased dramatically in the ovarian granulosa, thecal and stromal cell populations, as well as in the uterine epithelium, of diabetic mice compared to controls. Both ovarian and uterine lipase activities were greatly increased in the db/db mice compared with controls. These data suggest that the structural adiposity and functional decline in reproductive tract condition of the db/db mutants are related to the enhanced cellular lipid deposition observed in this species.

Barlett, P. B., Department of Anatomy, Cleveland Chiropractic College, Kansas City, MO 64131. THE REPRODUCTIVE OUTCOME OF MALE SPRAGUE-DAWLEY RATS EXPOSED TO AGENT ORANGE. Agent orange was the major defoliate used during the Vietnam War between 1962 and 1971. This study applied the agent orange solution to the shaved backs of male rats, 5 days a week, for up to 360 days. Treated males were then mated with untreated females and the fetuses collected at 19 days of gestation. No effect was seen up to 300 days. After 300 days, there was an increase in the number of dead and resorped fetus, along with an increase in the number of cleft palates, hydrocephalus and eye defects. This represents a possibility of a genomic change in the sperm cells without rendering them incapable of fertilization.

Frazier, C. L., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. ELISA FOR DETECTION OF ANTIBODIES TO ST. LOUIS ENCEPHALITIS VIRUS (SLE) AND LACROSSE ENCEPHALITIS VIRUS (LAC). SLE virus has been isolated, LAC infections have been serologically diagnosed and vectors and reservoirs for both viruses are found in Mo. There have been no statewide studies to determine the incidence, distribution, biology and significance of these viruses. An ELISA for antibody detection that does not require gradient purified antigen would be a useful tool when facilities are limited. Minimal background is required to allow visual evaluation of the plates. The background found with a capture antigen ELISA was unsatisfactory. Significant improvement was not achieved with the use of several blocking agents and/or purification of the coating antibody. A capture IgG assay has been developed that gives strong positive reactions with reference positive sera and minimal background with negative sera. The assay has been used in a pilot serosurvey and the results were consistent with CF results.

Murti, S., Melethil, S., and Sandmann, B. J., School of Pharmacy, University of Missouri-Kansas City, Kansas City, MO 64110; **Trueworthy, R.**, University of Kansas Medical Center, Kansas City, KS 66102. ASSAY OF 6-MERCAPTOPYRINE IN HUMAN PLASMA BY HPLC. HPLC was used to quantify levels of 6-mercaptopyrine which is extensively used in the therapy of acute lymphoblastic leukemia. Extraction of the drug from plasma spiked with the internal standard 6-methylthio-2-hydroxypurine was effected using acetonitrile and dichloromethane. The equipment used was as follows: Altex 110-A pump, Shimadzu SIL-6A systems controller, IBM C18 column, Kratos Spectroflow 783 detector and Shimadzu Chromatopac C-R3A integrator. The analysis was carried out at 322 nm at a 0.002 AUFS level, using 0.5% acetonitrile/0.5% acetic acid/99% water as the mobile phase. The method was shown to be sensitive to GMP concentrations of 5 mcg/ml.

Kingsland, S., 10244 Richview Drive, St. Louis, MO. HYDROGEN BONDING AND ELECTROPHORETIC BLOTTING TRANSFER. Prior nitrocellulose processing experience led to the conclusion that the variation of the physical properties of this product were a function of the degree of hydrogen bonding. The extension of this conclusion to the currently popular electrophoretic blotting transfer technology allows the understanding of many aspects of the selectivity and behavior of this phenomenon.

Corrigan, G. E., Laboratory, St. Louis VAMC, St. Louis, MO 63125. THE ROLE OF CHEMICAL MICROSCOPY IN METHADONE MAINTAINENCE MONITORING. Methadone replacement therapy is a widely used clinical method for the control of heroin addiction. Most programs of methadone maintainence weekly chemical surveillance of patients. The role of microscopy of the crystalline components of the urine is explored as to feasibility, cost, reliability, and general utility.

Chemistry

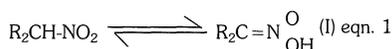
Thompson, C. C., Department of Chemistry, Southwest Missouri State University, Springfield, MO 65804. PHYSICAL CHEMISTRY: TWENTY YEARS OF CHANGE. The past two decades have seen significant changes in the overall content of and the relative emphasis on material included in the undergraduate physical chemistry course. As with other areas of chemistry, many topics formerly presented at the graduate level have found their way into the undergraduate curriculum. Upon returning to the physical chemistry classroom after an absence of eighteen years, the author has systematically compared current textbooks and his own lecture materials with those of twenty years ago. As a means of stimulating further discussion, some salient features of these comparisons will be presented.

Bertrand, G. L., Department of Chemistry, University of Missouri-Rolla, Rolla, MO 65401. MICROCOMPUTER-SIMULATED EXPERIMENTS IN PHYSICAL CHEMISTRY. Simulations of physical chemistry experiments have been programmed for the Apple IIe microcomputer. These programs involve animation of the experiment, and require some degree of control (timing, temperature, pressure, etc) by the operator. The programs were designed for use as lecture demonstrations, pre-lab preparation, or as tutorials, but some are now being used in place of experiments.

Programs to be demonstrated include: Density by the Buoyancy Method (solids, liquids, and liquid mixtures), the Ubbelohde Viscometer, and the Iodine Clock Reaction (batch and flow methods).

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enol-keto tautomerization of ketones. The "enol"-like form for nitroalkanes is called an aci-nitroalkane and has been reported to be present to the extent of 0.3% in 2-nitropropane. We have reinvestigated the tautomerization of several mono-nitroalkanes by use of nmr spectroscopy and find that this tautomerization is unimportant in describing the properties of these compounds in either acid or neutral solution.

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professional chemists. Chemistry departments which implement undergraduate programs meeting ACS national standards are accredited by the Society. Too, the American Institute of Chemists (AIC) maintains a Code of Ethics, the national norm of professional behavior expected of those who practice the profession of chemistry. A synergism of the academic standards established by the ACS and the ethical norms promulgated by the AIC produces a true professional in a successful undergraduate curriculum. This report considers deviations from the ACS standards and the AIC norms. Some variations serve to enrich the curriculum and enhance the development of professional ethics, while other deviations emasculate the academic standards, compromise the ethical construct, and abuse the spirit and intent of both.

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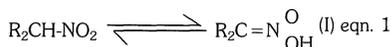
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handled the coloring very well. The setup and implementation of the composite graph coloring were done without much difficulty.

Boehning, R. L., Computer Science Department, Southwest Missouri State University, 901 S. National, Springfield, MO 65804. USING TWO LEVELS OF PARALLELISM IN SOLVING AN INTEGER LINEAR PROGRAMMING PROBLEM. A parallel integer linear programming algorithm involving two levels of parallelism was implemented on the Encore Multimax and The Sequent Balance computers. A comparison is made using a pivot operation as the module of parallelism versus using the calculation of a single row of the simplex as the module of parallelism. For a given number of processes, it is shown that the row module gives the best time, while the pivot module actually does fewer calculations.

Conservation

Collett, A. J. and Weber, W. R., Department of Biology, Southwest Missouri State University, Springfield, MO 65804. THE VASCULAR FLORA OF BONA GLADE NATURAL AREA, DADE COUNTY, MISSOURI. A survey of the vascular flora of Bona Glade Natural Areas, Dade County, Missouri, was made between September 1985 and December 1986. An annotated checklist of 265 taxa was compiled, representing 69 families and 173 genera. Seven plant communities were described and mapped on the basis of dominant species, as well as the topography, soils, and geology. The entire study area is underlain by Pennsylvanian Channel Sandstone and represents one of several localities for the federally endangered species, *Geocarpon minimum*. This taxon, which is very abundant within the study area, is found in Missouri only on Channel Sandstone. No floristic studies involving this unique substrate have previously been published.

Kaszubski, J. L. and Sharp, J. R., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. DISTRIBUTION OF MUSSELS (UNIONIDAE) IN MISSISSIPPI COUNTY, MISSOURI. From June through October 1987, 207 mussels (Unionidae) were collected from 32 sites located throughout Mississippi County in Southeast Missouri. Nineteen species from twelve genera were represented in the sample. Of these, eleven species were county records. These were *Amblema plicata*, *Anodonta suborbiculata*, *Corbicula leana* (an introduced Asian species), *Lampsilis teres anodontioides*, *Lampsilis teres teres*, *Leptodea fragilis*, *Ligumia recta*, *Obovaria olivaria*, *Potamilus alatus*, *Potamilus ohioensis*, and *Tritogonia verrucosa*. Two endangered species were also found, *Anodonta suborbiculata* and *Potamilus purpuratus*. Specimens of *A. suborbiculata* were found in relatively large numbers at seven of the 32 collection sites, perhaps indicating a substantial population. Individuals of *Potamilus purpuratus* were collected at six of the sites, but only in small numbers. All specimens are stored in the Southeast Missouri State University's regional museum. Partially funded by Missouri Department of Conservation.

Humphrey, R. C. and Weber, W. R., Department of Biology, Southwest Missouri State University, Springfield, MO 65804. GERMINATION ECO-PHYSIOLOGY OF *GEOCARPON MINIMUM*. This project was undertaken in an attempt to elucidate the germination requirements of the federally endangered species, *Geocarpon minimum*. Experimentation consisted of aseptically plating seeds on agar-agar in petri plates and placing them in one of six growth chambers which were held at different temperatures (5,10,15,20,25,30°) for thirty day time intervals. All chambers were held at a $1\frac{1}{2}$ photoperiod. Four treatments were tested over the temperature range using seeds from 1986 and 1987; the treatments were leaching (5,10,15 days), heat afterripening (30,60,90 days), cold stratification (30,60,90 days), and darkness. Germination percentages were calculated and the means were statistically analyzed by the use of a one-way ANOVA. The results showed a significantly higher germination percentage and tolerance of a wider temperature range for all 1986 seeds compared to those collected in 1987. The afterripening treatments showed a significantly higher germination percentage and wider temperature range than any other treatments. All of the seeds that germinated, regardless of temperature or treatment, formed a rosette of 1-2 set of leaves with a dormant epicotyl. These results support the hypothesis that *Geocarpon* is a strict winter annual with a double dormancy life cycle.

Harding, R. S. and Tillman, D. L., Biology Department, Missouri Southern State College, Joplin, MO 64801. COMPARISON OF TWO STREAMS AT PRAIRIE STATE PARK: USING BENTHIC MACROINVERTEBRATES AS INDICATORS OF STREAM QUALITY. Species diversity was used to determine stream quality in Fleck Creek and First Nicholson Creek at Prairie State Park. In both creeks, benthic macroinvertebrates were collected using the kick-net method. Samples were collected in June and April of 1987. In both samplings, First Nicholson Creek had a diversity of 2.42. There were no organisms found in any sample collected from Fleck Creek. These numbers reflect the nature of the two creeks. First Nicholson drains a basin consisting of prairie and cultivated land, while Fleck Creek originates from land disturbed by strip mining.

Whitmar, W. W. and Stiehl, R. B., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. A QUANTATIVE DESCRIPTION OF NESTING SITE COMPONENTS OF THE MISSISSIPPI KITE (*ICTINIA MISSISSIPPIENSIS*). We located fourteen Mississippi Kite nests on the Mississippi River from Ste. Genevieve to 18 km south of New Madrid, MO. We calculated 38 habitat variables within a 0.04 ha circle centered on the nest tree. The variables included tree species, height and dbh; nest height, location and support structure; basal area of overstory and understory tree species; and site topography. Similar variables were calculated for two 0.04 ha non-nest plots associated with each nest. A stepwise discriminant functional analysis indicates that basal area, the number of tall trees, and tree height vary significantly between the nest plots and the

non-nest plots. Student's t-test results revealed that height classes, tree height, total basal area, canopy height, and variation in canopy height were significantly different between nest plots and non-nest plots. Supported by the Missouri Department of Conservation.

Pobst, B. S. and Stiehl, R. B., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. TEN YEAR TRENDS IN LARGEMOUTH BASS AND BLUEGILL POPULATION CHARACTERISTICS IN EIGHT SOUTHEASTERN MISSOURI LAKES. We predicted population characteristics of Largemouth Bass (*Micropterus salmoides*) and Bluegill (*Lepomis macrochirus*) in eight southeastern Missouri lakes based on habitat and biological variables and the relationship among these variables to age structures, relative weight (Wr) and population densities. Variabilities in age structures and Wr may be attributed to differences in water temperature, food availability, fertility and overall water clarity. Management strategies stressed vegetation control and increased lake fertility. We pinpointed specific populational problems and proposed management strategies based on plotted proportional stock densities (PSD) and Wr for each lake. Supported by Missouri Department of Conservation.

Janzow, F. T., Kaszubski, J., and Sharp, J., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. A STUDY OF THE ECOLOGICAL STATUS AND SPECIES ASSOCIATIONS OF AMMOCRYPTA VIVAX. *Ammocrypta vivax* and *A. clara*, unusual darters, are thought to be declining in number throughout southeast Missouri. We collected fish from southeast Missouri stream and ditch sites distributed from Bollinger county to the southern edge of Dunklin county to assess the abundance of these darters, and to determine changes in species assemblages associated with these sand darters. *A. vivax* appears to be more abundant than previously thought. *A. clara* is more limited in distribution but also is locally abundant in southern counties. Previous assessments of the status of these species may have been biased by sampling techniques which did not account for the fact that these darters burrow deeper into the substrate than thought. A video recording of burrowing behavior in several types of substrates will be shown. As expected species associated with these darters change from north to south. *A. vivax* is distributed throughout the survey sites, suggesting that this species is more tolerant of varying habitat conditions than many other fish of the southeast Missouri region.

Messick, J. P., Department of Biology, Missouri Southern State College, Joplin, MO 64801. DISTRIBUTION OF THE BADGER IN SOUTHWESTERN MISSOURI. The North American badger, *Taxidea taxus*, is widely distributed over parts of the western and central United States, but its status in southwestern Missouri is unclear. The purpose of this ongoing study is to solicit and evaluate sightings of badger, principally from western and southwestern Missouri. Methods include advertizing for sightings and examination of fur harvest reports. Most reliable sightings to date originated in Barton county. Fur harvest statistics suggest that the badger may be expanding its range in Missouri. Support provided by the Missouri Prairie Foundation and Missouri Southern State College.

Engineering

Woodson, R. J., Department of Civil Engineering, University of Missouri-Columbia, Columbia, MO 65211. A NUMERICAL MODEL TO PREDICT THE PERFORMANCE OF THE HYDRAULIC CAPSULE PIPELINE SYSTEM. Hydraulic capsule pipeline (HCP) is a mode of transportation in which the freight takes the shape of cylindrical capsules suspended in flowing water. One technical drawback of HCP is the lack of existing pumps capable of pressurizing capsule pipe flow. An eight valve, three pipe bypass scheme allows capsules continuous passage bypassing the conventional pump that drives the pipeline. Periodically, sudden valve closures create violent pressure waves, the control of which is the subject of this paper. A numerical model predicts that larger pump heads increase the magnitude of transients, and that valve stroking is partially effective in reducing the peak transients. The numerical model uses Gaussian elimination, characteristic solutions and loop and branch equations to determine pressure head and discharge and optimum pipeline design as a function of pipe diameter, bulk discharge, valve speed, and pipe lengths among others.

Zumwalt, K. W. and El-Sayed, M. E. M., Department of Mechanical and Aerospace Engineering, University of Missouri-Columbia, Columbia, MO 65211. DEVELOPMENT OF A CODE UTILIZING A CONTINUUM MECHANICS SHELL ELEMENT FOR THE OPTIMIZATION OF LAMINATED COMPOSITE STRUCTURES. To date, development of laminated composite shell elements has usually depended on the extension of classical theory by the use of shear correction methods. The restrictions imposed by these methods make the development of a general code for optimizing laminated composite structures difficult. With recent continuum mechanics shell theories, however, the development of a laminated composite shell element with an extensible cross section and interlaminar shear is possible. This element will be used in an optimization code with fiber orientation and ply-thickness as the design variables.

Kessler, R. E., Brooks, S. L., Hummel, K. E., and Schaefer, R. M., Allied-Signal Inc., Kansas City Division, Kansas City, MO 64141. A STRATEGY FOR THE INCORPORATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGY INTO A MANUFACTURING PLANT. Activities began in 1982 to prepare the Kansas City Division factory for acceptance and use of artificial intelligence technology. The knowledge to assess and evolve local applications was developed in the context of the existing management environment and capabilities. A

strategy for developing initial applications in the computer aided process planning area was pursued. This application area had three advantages: (1) process planning was of strategic significance to the Kansas City Division, (2) the technical direction of computer aided process planning (CAPP) included heuristic generation of plans and (3) the organizational potential for technology acceptance was greatest in engineering where development could be carried out. Two major projects have been the vehicles for change. XCUT (eXpert CUT planner) is an expert system project to automate the process planning function of operations planning for machined place parts. Prototypes of XCUT have been successfully demonstrated and it is planned for deployment in 1989. A successful CABPRO (CABLE PROcess planner) prototype has been demonstrated and it will be deployed in the summer of 1988. CABPRO is an expert system to assist engineers in the development of cable fabrication work instructions. Issues that are discussed include technology assessment, organizational acceptance of change, teamwork, expert system project development, and integration in the CIM environment. Assessment today, suggests that the strategy has been successful. Supported by the U.S. Department of Energy under contract number DE-AC04-76-DP00613.

Leininger, G., The Intelligent Industrial Systems Center, University of Missouri-Rolla, Rolla, MO 65401. THE INTELLIGENT INDUSTRIAL SYSTEMS CENTER AT THE UNIVERSITY OF MISSOURI-ROLLA. The University Board of Curators created the Intelligent Industrial Systems Center as an Eminent research program at the University of Missouri-Rolla in 1986. The research program has identified three theme directions for research that could have a significant positive impact on the industry base within the State of Missouri. The Production Planning and Scheduling theme addresses the needs of the manufacturing and transportation sector. The Crisis Management theme looks into failure detection, fault diagnosis, troubleshooting and emergency response problems for a broad range of business applications. The Risk Assessment theme concentrates research in the areas of financial planning, technology assessment and marketing awareness. Industry support for an Industrial Liaison Program will begin in summer 1988 to help identify research projects and to assist in the technology transfer of research results to the program sponsors.

El-Gizawy, A. S., Department of Mechanical and Aerospace Engineering, University of Missouri-Columbia, Columbia, MO 65211. RECENT DIRECTIONS OF COMPUTER-AIDED PROCESS DESIGN IN MANUFACTURING. Changing manufacturing from an experience based to knowledge based system is an important step toward enhancing the competitiveness of U.S. industry. Through use of computer-aided methods, heuristic, and physical modeling techniques, the existing processes can be improved and new ones may be fully developed and controlled. Recent progress in these design tools is discussed, highlighting current capabilities and indicating their impact on achieving future goals in manufacturing.

Dimarogonas, A. D., W. Palm Professor of Mechanical Design, Washington University, St. Louis, Missouri. A TENTATIVE MODEL FOR THE COMPUTER AIDED DESIGN PROCESS. Computer Aided Design provides computer support for the design process. Almost all aspects of the design process have been influenced by the introduction of computer methods. A coherent integration, however, of computer methodology with the design process requires a systematic formalization of the latter. A formal computer aided design process should: (a) Describe the process in a systematic way. (b) Integrate all available design automation aides, such as computer graphics, modelling and simulation, optimization, numerical solution of field problems, into a working system. (c) Provide continuous interaction and dialogue with the designer and a balance between the exhaustive tendency of computer methods and the heuristic approach of the designer. (d) Provide the nucleus for standardization of machine design automation modules. (e) Compile a database with basic essential information needed by the design process.

Haubein, H. D., A. B. Chance Co., 210 North Allen, Centralia, MO 65240. INTEGRATION OF CAD/CAM/CAE INTO THE MANUFACTURING ENVIRONMENT. To realize the benefits of the subject tools it is necessary for the user company to recognize the need to integrate their use between various disciplines. Without this recognition, Design Engineers will continue to work independently and then pass the design to Manufacturing Engineers who in turn will pass it to Production. By integrating these functions throughout the operation the time from product design through production can be shortened without the need for revisions due to the inefficiencies we have previously seen.

Bickel, T. R. and O'Brien, D. J., Black & Veatch Engineers-Architects, 1500 Meadow Lake Pkwy., Kansas City, MO 64114. CONCEPTION, DESIGN, AND CONSTRUCTION OF POWER PLANTS USING A CENTRALIZED DATABASE AND 3-D GRAPHICAL REPRESENTATION. The database, part of B & V's POWRTRAK system, localizes information specific to the design of a power plant thus eliminating data duplication and design inconsistencies resulting from time lags in exchanging design information between engineering disciplines. The 3-D graphical model is a more accurate representation than a physical model and provides a visual display of the current plant design. A relational database stores all pertinent information such as scheduling, equipment design requirements, procurement, etc. This database exchanges information with computer programs that aid in the design of the plant. The stored information is accessible to all those involved in the conception, design, and construction of the plant, but can be changed only by those authorized to do so. The efficient transfer of information increases productivity and quality and eliminates costly last-minute changes once construction is started. POWRTRAK and the associated 3-D graphical system shortens the design process, reduces the cost of the plant, and enhances the quality of the finished product.

Heimann, B., Research and Development Manager, Orscheln Corporation, Moberly, Missouri. FLEXIBLE MANUFACTURING THROUGH EXCELLENCE — AN R & D PERSPECTIVE. American manufacturing is learning that in order to survive it must compress the "concept to product" cycles. Tools available for that task include JIT, SPC, and CIM which are now being implemented at Orscheln. The mission statement of Orscheln R & D includes development of new products and processes within the flexible manufacturing arena. Development work is accomplished on production equipment with a mixture of mechanical engineers, chemists, and chemical engineers from R & D who work side-by-side with production personnel. The R&D lab consists of only basic analytical tools for observation and measurement. The design cycle is compressed through the elimination of scale up. The manufacturer of tomorrow will continue to require flexing of not only manufacturing processes, but also management styles. The manager of tomorrow must embrace change in order to deal with the integration of electronic information systems and manufacturing systems without forgetting about people.

Hetherington, R. G., Computer Science Program, University of Missouri-Kansas City, Kansas City, MO 64110. THE CENTER FOR ADVANCED TECHNOLOGY IN TELECOMMUNICATIONS AND COMPUTER NETWORKING. The Computer Science Program (CSP) at The University of Missouri-Kansas City (UMKC) has designed and started developing a high technology organization to conduct basic and applied research in telecommunications and computer networking in response to the State of Missouri Request for Proposal #B700690. This RFP called for creation of a few technology centers to be created and funded for five years by the state in order to stimulate economic growth. A center for Advanced Technology (CAT) is a consortium of academic and business/industrial organizations whose goal is to assist existing companies and to attract new companies by creating new technology and carrying it to the market place. The UMKC CSP has obtained commitments to help with the planning and development of its CAT from seven telecommunication corporations, two large corporate users of telecommunications, two academic units, two technology transfer corporations and one economic development organization. A planning board, made up from consortium members will develop operating policies and procedures, formulate a marketing plan, and explore various avenues for programmatic and research funding.

Walden, Charles H., Department of Mechanical and Aerospace Engineering, University of Missouri-Columbia, Columbia, MO. FLEXIBLE AUTOMATION CHALLENGES ENGINEERING AND TECHNOLOGY EDUCATION. Flexible automation offers significant opportunity for improvement of American industrial productivity. To implement this technology requires engineers and technicians capable of engaging it effectively. Engineering and technology education programs must provide basic instruction in the new automation technologies. A laboratory has been established at the University of Missouri-Columbia for this purpose. This presentation describes the activities at UMC in instruction for flexible automation.

Bagge, E. A., TURN-Key Manufacturing Systems; 482 Manorcrest Lane, Ballwin, MO 63011. OUR WIDE-SPREAD CURSE OF 'COUNTER-PRODUCTIVITY'—A LOOK AT ITS SYMPTOMS, CAUSES, and REMEDIES. A presentation summary from 35+ years spent reviewing and analyzing manufacturing business operations while searching for practical ways to increase productivity. This summary focuses on widespread problems found in the basic business operations present in all manufacturing companies—broadly existing problems that are essentially independent of such variable business factors as product/market environments, high-low technology levels used in Sales, Engineering, Materials, Shop, or Accounting operations, and of business size, etc. The Symptom/Cause review is keyed to a schematic definition of manufacturing business operations. This schematic/graphic baseline is then applied to defining counter-productivity problems relative to basic manufacturing work-flow patterns and their related operations data flow. Suggested REMEDIES are keyed to the observed causes of our 'Poor-Productivity Affliction' (now near epidemic level). Presentation's GOAL: enable attendees to look more critically at THEIR businesses, recognizing symptoms and causes hampering their overall productivity, and then apply objective perspectives to identify and administer remedies to improve THEIR cost control, product quality, customer service, and profitability—thus to gain their help in reversing U.S. trend toward the demise of our industrial-based economy.

Ho, Y. S., Research Assistant, and **El-Gizawy, A. S.**, Assistant Professor, Mechanical and Aerospace Engineering, University of Missouri-Columbia, Columbia, MO 65211. ECONOMICAL CONSIDERATIONS AND PRODUCT DESIGN RULES FOR ROBOT ASSEMBLY. Flexible manufacturing system, especially the applications of assembly robots in industry, have been studied for many years. However, an important concept to be addressed is that not all products are suitable for flexible manufacturing. Due to batch size and the assembly characteristics, it may not be possible to assemble a product economically using robots.

A case study shows the importance of design for assembly. The most fundamental factor affecting the assembly cost is the design of the product rather than the selection of assembly system.

Production costs can generally be determined during the part and product design stage. If proper consideration is given to manufacturing and assembly during the design stage, the production costs can be significantly reduced.

This paper presents appropriate design rules for ease of robot assembly and a means of estimating product assembly costs.

Nateghi, F. and Liu, H., Department of Civil Engineering, University of Missouri-Columbia, Columbia, MO 65211. SEVERE WINDSTORM CLASSIFICATION: TORNADO vs DOWNBURST. At midnight on June 16, 1985 a severe storm struck Columbia, Missouri. The storm affected the city's Regional Airport, leaving extensive damage to aircraft, automobiles, and also causing some structural damage. An investigation was carried out by the writers to determine the nature of the storm and the failure mechanism of all the damages caused by the storm.

Details of the investigations are given in a National Science Foundation report (Liu, H. and Nateghi, F., 1986.) This paper, based on the report, focuses on the storm classification. Investigation revealed that the storm was more likely a microburst instead of a tornado as officially classified by the meteorologists at the National Weather Service.

Nateghi, F. and Liu, H., Department of Civil Engineering, University of Missouri-Columbia, Columbia, MO 65211. WIND EFFECTS ON MOBILE HOMES. According to a study done by the National Science Foundation, wind disasters in the United States cause billions of dollars of damage to buildings, most of which are residential or mobile homes. Currently, mobile homes account for 30% of single-family housing in the United States. As the number of mobile homes increases, so does their vulnerability to wind-induced damage. Relatively high ratios of wind load to dead load tend to make mobile homes more sensitive to wind effects. This paper reviews the current laws and standards concerning mobile homes. It discusses possible damage mechanisms of mobile homes in a wind storm and finally offers a method to calculate effective wind velocities and proper tie-down systems.

Nateghi, F. and Liu, H., Department of Civil Engineering, University of Missouri-Columbia, Columbia, MO 65211. BEHAVIOR OF WOOD CONNECTIONS: NAILS vs HURRICANE CLIPS. Wind disasters in the United States cause billions of dollars in damage to buildings, most of which are non-engineered structures such as houses. Wood-framed houses use connectors such as nails, straps, and toothed plates which offer inadequate resistance to the forces generated at the joints in high winds. Such structures have semi-rigid joints. This paper offers an experimental technique to measure the rigidity of such joints. This paper also compares the experimental data obtained for joints made of nails vs hurricane clips. The results indicate that hurricane-clip reinforced joints gave about 70% higher stiffness than the ones with nails only. Resisting moment capacity was also much higher and the joint was more ductile.

Waggoner, R. C., Mitchell, J. L. Jr., Smolen, T. M., and Schuth, R. A., Department of Chemical Engineering, University of Missouri-Rolla, Rolla, MO 65401. CAPABILITIES OF MICROPROCESSOR BASED INDUSTRIAL CONTROLLERS USED FOR ON-LINE GENERATION OF TITRATION DATA. The microprocessor based industrial controller has many capabilities beyond those used to implement the conventional Proportional-Integral-Derivative (P-I-D) algorithm. These capabilities are programmed to drive a neutralization so that data is obtained to compute a titration curve. A totalizer is used to generate an increasing signal which can be scaled to span the range of the test. This signal is transmitted as a set point for the P-I-D algorithm so that the controller output continually responds to the perturbation. The controller serves as a master in a cascade loop and transmits a set point to a slave flow controller. The instantaneous flow rate is transmitted to a second totalizer where it is summed to generate a cumulative flow value. Digital logic capabilities in the controller permit titrant flow to be adjusted within the measureable range of the titrant flow meter and enable the flow signal to be corrected to an actual value.

Environmental Science

Aide, M. T. and Tibbs, N., Department of Agriculture and Department of Earth Science, Southeast Missouri State University, Cape Girardeau, MO 63701. COBALT, NICKEL AND COPPER ACCUMULATIONS IN FE & MN MASSES REMOVED FROM SOILS. Two soils along the Castor River in S.E. Missouri were found to contain Fe & Mn aggregates. These aggregates are recognized by their distinct shapes, colors and sizes. Chemical analysis of the aggregates and bulk soil shows these aggregates to be highly enriched in Fe, Mn, Ni, Co and Cu. Soil reactions >6 were found to be very conducive to Co, Ni, and Cu enrichment.

Krajicek, J. J. and Overmann, S. R., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. THE COMMON SNAPPING TURTLE *CHELYDRA SERPENTINA*: A BIOINDICATOR SPECIES FOR LEAD (Pb) CONTAMINATION IN AQUATIC ENVIRONMENTS - A PRELIMINARY REPORT. This study determined Pb levels, using atomic absorption spectrophotometry, in liver, bone, carapace, blood, brain, and muscle of turtles captured above and below sites of Pb contamination in the Big River. Results showed the tissue Pb levels in turtles captured from Pb contaminated sites were considerably higher than corresponding tissues of turtles from non-contaminated sites upstream. Further results showed the Pb concentrations in bone and liver were consistently higher than levels in other tissues. Data support the hypothesis that snapping turtles are useful bioindicators for Pb contamination in aquatic environments. Supported by the Missouri Department of Conservation.

Mantei, E. J., Department of Geosciences, SMSU, Springfield, MO DETERMINATION OF THE HEAVY METALS EMITTED FROM LANDFILLS USING THE SEDIMENTS FROM STREAMS WHICH DRAIN THESE SITES. The determination of the heavy metal content in the stream sediments draining a landfill may be an effective method to monitor landfill emissions. Some heavy metals which may exist in a soluble form within a landfill may be adsorbed or precipitated before leaving the landfill via surface waters or ground water because of an increase in pH of the waters carrying these soluble metals. However, other heavy metals may leave the confines of the landfill and are adsorbed or precipitated on the stream sediments in the surface waters resulting in a higher heavy metal content in these sediments above background quantities. A study of three sanitary landfills in the southeast Missouri area indicates that certain heavy metals appear to be emitted by each landfill site. In each case, the sediments from a nearby stream unaffected by the landfill acted as a control for this study.

McCairel, J. C. and Mills, S. H., Department of Biology, Central Missouri State University, Warrensburg, 64093. EFFECTS OF 2,5-HEXANEDIONE ON BODY TEMPERATURE AND BEHAVIORAL RESPONSES OF JAPANESE QUAIL (*Coturnix japonica*). Normal Japanese quail were compared to quail treated with 0.05%, 0.0005%, and 0.0005% 2,5-hexanedione during exposure to 25, 20, 15, and 10°C (n=40). The 0.05% group had leg temperatures that were lower than the control with the right leg temperature was always higher than the left (p<0.05). The frequencies of feather fluffing and activity in 0.05% treated group were lower when compared to that of the control group especially at 15 and 10°C. The most noticeable effect of the hexacarbons was observed in this highest dosage group. Core temperature among the groups subjected the various ambient temperature remained within the limits of normal body temperature. Gas chromatographic analysis indicated that low levels of this neurotoxic agent was associated with behavioral effects that limited the ability of the treated groups to temperature regulate. Support in part by the CMSU Center for Technology.

Sharp, J. R., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. THE EFFECT OF SALINITY ON CADMIUM TOXICITY AND FIN REGENERATION OF PENFISH, *LAGODON RHOMBOIDES*. Subadult penfish were acclimated to 10, 20, and 30 ppt salinity for 10-d to determine the effect of salinity acclimation on acute cadmium toxicity and fin regeneration. The 96h LC50 values, following an acute cadmium bioassay were approximately 35, 25, and 10 ppm Cd for the 30, 20, and 10 pptS acclimated fish, respectively. Fishes of each acclimation salinity were exposed to 3 sublethal Cd levels for 20-d, following partial amputation of the caudal fin, to determine the salinity-cadmium effects on fin regeneration. Fishes were fed daily and R values (regenerated length divided by total length × 100) were determined at 5-d intervals. The salinity-cadmium concentrations were 10 pptS-0.25, 0.5, 1.0 ppm: 20 pptS-0.5, 1.0, 2.0 ppm: 30 pptS-1.0, 2.0, 4.0 ppm. Fishes dosed in 10 pptS demonstrated reduced regenerative ability at all 3 Cd levels. Fishes exposed to 20 pptS demonstrated similar results at the two highest Cd concentrations, while fishes exposed in 30 pptS exhibited reduced growth at the highest Cd. Abnormal growth was noted among Cd exposed fish.

Fitzgerald, M. L. and Belshe, J. F., Department of Biology, Central Missouri State University, Warrensburg, MO 64093. THE ROLE OF BACTERIA AND PH IN IRON DEPOSITION FROM PERTLE SPRINGS WATER. This project was funded by the Missouri Academy of Science Endowment Fund and the Biology Department of CMSU. Iron is deposited in the sheaths of members of the iron deposition bacteria of the *Sphaerotilus-Lepthothrix* group. The deposition of iron from Pertle Springs water occurs rapidly and is accompanied by an upward shift in pH both in the natural setting and in the laboratory. In the laboratory this deposition is observed in the presence and absence of bacteria. The iron is found in the sheaths of the bacteria when they are present and as a precipitate in the flasks when the bacteria are absent. The quantitative result of our studies will be presented. The results of our study indicate a need for additional study of this problem.

Belshe, J. F., Department of Biology, Central Missouri State University, Warrensburg, MO 64093. DENSITIES OF DRAGONFLIES AT TWO PRAIRIES IN WEST CENTRAL MISSOURI. Few studies of dragonfly densities have been done in prairie habitat. The purpose of this study, which was funded by the Missouri Prairie Foundation, was to examine the density of dragonflies on Drover's Prairie (Benton Co.) and Friendly Prairie (Pettis Co.) as it might relate to water availability and management practices. The densities found in this study were much lower than found in other studies at prairie sites in Illinois. Overall densities of dragonflies were similar at the two sites but the species composition was different. The density and number of species were higher in baled areas at both prairies. Dragonfly density on the prairies, though much lower than over the water at a pond, were found to be independent of the distance from the pond were adequate data for analysis was available.

Exercise Physiology

Martin, D., Mayhew, J. L., and Salm, P., Kirksville College of Osteopathic Medicine and Division of Health and Exercise Science, Northeast Missouri State University, Kirksville, MO 63501. ESTIMATION OF FUN PERFORMANCE FROM TRAINING VARIABLES. The purpose of this study was to determine if training variable could estimate running performance in a 5K fun run. Thirty-seven participants returned questionnaires dealing with their training. In the 25 complete questionnaires, total miles run in the previous 2 months had the highest correlation with run time (r = -.74). Longest run in the previous 2 months (r = -.69), number of workouts/wk (r = -.64), average miles run/day (r = -.54), and training pace (r = .50) were also significantly related to run time. Percent of training performed continuously was the only training mode variable significantly related to performance (r = -.35). It was concluded that runners who train more times/wk with longer runs at faster pace perform better in short road races. Further research is warranted to determine which physiological factors are reflected by these training variables.

Salm, P., Salm, A., and Mayhew, J. L., Division of Health and Exercise Science, Northeast Missouri State University, Kirksville, MO 63501. COMPARISON OF LACTATE RESPONSES TO INCREMENTAL ARM AND LEG WORK. The purpose of this study was to determine lactate (HLA) and heart rate (HR) responses to progressive arm and leg ergometry work. Three male subjects performed arm cranking (60 rpm) for 3 minutes with an initial workload of 150 kpm/min. The load was increased in increments of 150 kpm/min after each 5-min rest period. During the arm testing, the Monark cycle ergometer was securely mounted to a table at shoulder height. The same ergometer and protocol were used for leg work. HR determinations were made by auscultation during the

last 30 seconds of each work bout. Finger prick samples of blood were obtained after the 3rd minute of rest for the determination of HLA concentration. Both HR and HLA were greater during arm than leg exercise at workloads above 600 kpm/min. The greater cardiorespiratory stress imposed by arm work than leg work has implications cardiac rehabilitation and orthopedic patients, as well as for athletes performing upper body work.

Thomas, T. R., Makalous, S. L., and Araujo, J., Exercise Physiology Lab, UMC, Columbia, MO 65211. **HAND-HELD WEIGHTS AND ENERGY EXPENDITURE DURING WALKING.** To assess the additional energy expenditure induced by carrying hand weights, eleven mildly obese subjects performed 30 minutes of normal walking at $3.4 \text{ m}\cdot\text{h}^{-1}$, walking with increased arm movement, and walking with increased arm movements while holding hand weights (1 lb each). Hand weights caused an increased HR (127 vs $120 \text{ b}\cdot\text{min}^{-1}$), oxygen consumption (VO₂) ($1.68 \text{ vs } 1.086 \text{ l}\cdot\text{min}^{-1}$), and 30 minute cumulative total energy expenditure ($171.5 \text{ vs } 159.7 \text{ kcal}$) over normal walking. Increased arm movement without weights did not significantly increase HR, VO₂, or energy expenditure over normal walking. The rate of fat energy use and the cumulative 30 minute fat use were similar in all exercise conditions, as were recovery energy expenditures. These results indicate that using hand weights increases the energy demands of walking but only to a small degree.

Arnold, M., Mayhew, J. L., and Bowen, J. C., Northeast Missouri State University, Kirksville, MO. **PUSHUP PERFORMANCE AS AN INDICATOR OF UPPER BODY STRENGTH.** The purpose of this study was to evaluate the use of a 1-min pushup test to predict bench press performance. College males ($n = 170$) and females ($n = 111$) performed a 1-RM bench press (BP) with free weights. Within 3 days each subject was tested for maximum 1-min pushup performance (PU). PU were adjusted for height ($\text{PU} \times \text{cm}$), for weight ($\text{PU} \times \text{kg}$), and for height and weight ($\text{PU} \times \text{cm} \times \text{kg}/100$). Pushups were moderately related ($r = .46$) to bench press. Body composition was estimated from skinfolds. The correlations between adjusted pushups and BP were: $\text{PU} \times \text{cm}$, $r = .54$; $\text{PU} \times \text{kg}$, $r = .69$; $\text{PU} \times \text{cm} \times \text{kg}$, $r = .74$. Lean body mass (LBM) had a high relationship to BP ($r = .81$). A multiple regression equation using LBM and PU could provide a reasonable ($R = .87$) estimate of BP. Because of the large error noted when predicting BP, however, PU or adjusted PU is not an accurate reflection of upper body strength.

Myers, B., Ware, J., and Mayhew, J. L., Division of Health and Exercise Science, Northeast Missouri State University, Kirksville, MO 63501. **CHANGES IN MUSCULAR SIZE AND STRENGTH FOLLOWING WEIGHT TRAINING.** The purpose of this study was to determine the changes in anthropometric dimensions and strength resulting from weight training. Fourteen males were measured for biceps (BC) and chest circumferences (CC), upper arm cross-sectional area (CSA), weight, % fat, and bench press (BP) strength before and after 12 weeks of weight training. There was a 17% increase in BP performance ($p < .07$) but only 1.7, 2.0, and 3.9% increases in BC, CC, and CSA ($p < .59$), respectively. Correlations between changes in BC, CC, and CSA and changes in BP were insignificant ($r = -.30 - .30$). The changes in BP strength following a short-duration training program were not explained by changes in muscular size. The greater increases in strength than in muscular size were probably due more to neuromuscular adaptations than hypertrophy. Further research is needed to determine the time course of changes in size and strength resulting from strenuous weight training.

Kurth, A., Ghena, D., Thomas, M., and Mayhew, J. L., Division of Health and Exercise Science, Northeast Missouri State University, Kirksville, MO 63501. **PREDICTION OF ISOKINETIC LEG STRENGTH FROM ANTHROPOMETRIC DIMENSIONS.** The purpose of this study was to predict quadriceps extension and hamstring flexion strengths from anthropometric dimensions. Male athletes ($n = 80$) gave their informed consent to be evaluated for leg strength at 60, 120, 300, and 450 deg/sec using a Biodex isokinetic device and for structural dimensions. Multiple regression analysis selected thigh cross-sectional area, height, and weight to predict torques at all speeds. The multiple correlations ranged from .54 to .80. Cross-validation of the torque prediction equations on 25 similar subjects produced correlations of $r = .51 - .76$ for estimating isokinetic strength. It was concluded that strength-size relationships can be used to estimate leg strength levels in male collegiate athletes. These findings may have useful application for sports screening to prevent injury.

Geography

Richardson, S. P., Southwest Missouri State University-Springfield, MO. **A GEOGRAPHIC ANALYSIS OF DOWNHILL SKI AREAS IN MICHIGAN'S LOWER PENINSULA.** Twenty-six downhill ski areas were studied concerning the correlation between the lift capacity present at a ski area, the vertical drop of the area's slopes and the distance of the ski area to a major highway. A large lift capacity present at a downhill ski facility is assumed to be related to the economic success and stability of an area. The research hypothesis is that a ski area with a large vertical drop and also located near a major highway would show a correspondingly higher lift capacity. Statistical tests revealed the correlations were not as strong as initially anticipated. Additional research incorporating a larger sample and also variables concerning chronological and economic data is recommended.

Rollinson, P. A., Department of Geosciences, Southwest Missouri State University, 901 S. National, Box 87, Springfield, MO 65804-0089. **THE GEOGRAPHY OF ELDERLY SINGLE ROOM OCCUPANCY (SRO) TENANTS.** Single Room Occupancy (SRO) hotels, located in inner cities throughout the nation, offer housing to the poor elderly. Today the elderly SRO population is faced with life threatening change: both by a rapid decline in

the SRO housing stock and a demise in the goods and services offered in the immediate environment that make independent living in the SROs possible. Using the sample of elderly SRO tenants in Chicago, this paper documents their geographical experience.

These tenants are shown to have very constrained everyday geographies. Movement beyond the refuge of their rooms is severely limited by their own physical capability constraints and the powerful constraints imposed by the neighborhood environment. Overlooked by planners, social service agencies and society at large this population is shown to be in desperate need of assistance.

Grabow, A. J., Crowder College. THE MEXICAN ECONOMY-YESTERDAY AND TODAY. The Presenter will examine the economy of Mexico with particular reference to "La Crisis", i.e., hyperinflation and the peso falling uncontrollably downward coupled with a staggering international debt. The Presenter will view the history of the Mexican economy over the past quarter century, including personal observations spanning the twenty-five years from 1963 (his undergraduate degree, University of Texas-El Paso) to a current January 1988 CCIS Faculty Seminar, Mexico City, University of the Americas, Puebla focusing on the Mexican economy, and will include developments in the Mexican economy that may unfold between January 1988 and the April 1988 meeting of the Geography Section of the Missouri Academy of Science. Focus will be on three separate and distinct viewpoints as to causation of "La Crisis"; the American view, the Mexican government view, and the view of the Mexican populist Left.

Reddick, R., Hixson, B., and Robertson, A. C., Department of Earth Science, Southeast Missouri State University, Cape Girardeau, MO 63701. A STUDY OF HEAT ISLAND PROPERTIES OF WEST PARK MALL. Urban heat island effects have been observed for cities, towns, and large shopping malls. The researchers hypothesized that similar effects would be evident at a mall in Cape Girardeau. A similar study was completed for the Woodfield Mall near Chicago, IL (Norwine, 1972). Temperature readings were collected between October 26 and November 20, 1987. Temperature data were obtained north, south, east, and west of the West Park Mall. Data were collected from 23 sampling points during the study period. The results illustrated heat island properties were present. Average differences of .3°F, .4°F, 2.4°F, and 1.3°F were found north, east, south, and west, respectfully, from the mall.

Gerlach, R. L., Southwest Missouri State University, Springfield, MO 65804. GERMANS AND SCOTCH-IRISH IN THE NINETEENTH CENTURY OZARKS: A CONTRAST IN CULTURES. The two principal national-origin groups to settle in the rural Ozarks in the nineteenth century were the Germans and the Scotch-Irish. These two groups represented contrasting cultures in terms of social organization, settlement patterns, agriculture and material culture. Germans relied on land quality while the Scotch-Irish versatility in extracting a living from marginal lands. The Scotch-Irish utilized an open range system of land tenure almost unknown to Germans. The Scotch-Irish emphasized livestock while the Germans relied more heavily on grains. The Scotch-Irish invested little in their farms compared to neighboring Germans. Locational stability was a feature of German areas while mobility characterized the Scotch-Irish. These and other differences between the two groups are analyzed.

Geology/Geophysics

Nold, J. L., Department of Earth Science, Central Missouri State University, Warrensburg, MO. MASSIVE SANDSTONE UNITS IN THE PROTEROZOIC PRICHARD FORMATION, MONTANA, IDAHO AND BRITISH COLUMBIA. The Prichard Formation of the Belt Supergroup of western Montana, northern Idaho and southeastern British Columbia is a sequence of thin to thick bedded, laminated argillites, siltites, and quartzites. These rocks seem to have been deposited in deep water in a basin developed from growth faulting. Within the formation are occasional massive sandstone layers up to six hundred feet thick that do not show any internal bedding features. The units are not continuous laterally and thin to feather edges within several miles. The massive sandstone layers are clast-poor at most localities but clast-rich zones have also been found. The sandstone is composed mostly of quartz and fine-grained muscovite and biotite. Regional metamorphism averages biotite zone and in places is up to garnet zone. This obscures the original mineralogy of the sedimentary rock, but before metamorphism, the rock was probably in argillaceous sandstone. At most localities the massive sandstone unit is sandwiched between two dioritic Purcell sills. The sandstone units may have originated by disruption of non-lithified sediments and the disruption may have been caused by fluidization related to sill intrusion.

Karakus, M., Hagni, R. D., and Spreng, A. C., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. CATHODOLUMINESCENCE MICROSCOPY OF SEDIMENTARY IRON ORES, ALSACE-LORRAINE, FRANCE. Cathodoluminescence microscopy has been found to provide a superior technique for the detection and study of the morphology, size, abundance, and distribution of a large variety of phosphate grains in Jurassic (Aalenian) ironstones from the Alsace-Lorraine limonite district of northern France. Microproplites of crustacean (*Faureina*) and mollusk feces are the dominant phosphate grains; they constitute 80% of the total phosphate grains. Other phosphate grains include intraclasts, rings and cortices in ooids, phosphate-replaced ooids and bioclasts, phosphatic shells (*Lingula*), fossil in-fillings and casts, fish teeth, phosphatic laminae, and cements between goethite ooids. The cathodoluminescence is activated by the presence of Mn^{2+}

and the rare earth elements, Dy^{3+} , Sm^{3+} , Tb^{3+} , and possibly Eu^{2+} . Most of the phosphate grains are indistinguishable from goethite by ordinary transmitted light microscopy, although some light to medium brown phosphate grains locally can be distinguished.

Hagni, R. D., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. A COMPARATIVE ORE MICROSCOPIC STUDY OF THE SEDIMENT-HOSTED STRATIFORM COPPER DEPOSIT AT CRETA, OKLAHOMA WITH THE EUROPEAN KUPFERSCHIEFER. Although the Creta and Kupferschiefer deposits are similar in some respects, they are quite different in other respects. Both deposits are thin, conformable, laterally extensive, and contained within organic matter- and pyrite-rich greenish gray to dark gray shales that are Permian in age with similar palynological assemblages. Ore microscopic study shows that both ores are very fine-grained and contain abundant pyrite, digenite, djurleite, anilite, and chalcocite. The deposits differ mineralogically in that bornite and chalcopyrite are abundant only in the Kupferschiefer. Replacements of megaspores are an important constituent in the Creta ores, but represent only a minor form of copper occurrence in the Polish Kupferschiefer ores. Copper sulfide replacements of colloform pyrite are common in Creta ores, whereas replacements of framboidal pyrite are more important in the Kupferschiefer. Silver is recovered from both copper ores, and occurs as stromeyerite, argentiferous chalcocite, and argentiferous djurleite at Creta, and as stromeyerite, jalpaite, and in solid solution in other sulfides in the Polish Kupferschiefer.

Moeglin, T. D., Department of Geoscience and **James, H. R.**, Department of Agriculture, Southwest Missouri State University, Springfield, MO 65804. DETERIORATION OF FRAGIPAN SOILS IN THE MISSOURI OZARKS. Five pedons with fragipan horizons and three pedons lacking fragipanic horizons were sampled to determine the stability of the fragipan soils and to document the systematic changes between the two soil types. Kaolinite, illite (both 2M1 and 1M polytypes), montmorillonite, random interstratified illite-montmorillonite, and regular interstratified illite-montmorillonite were positively identified by x-ray diffraction. No consistent general trends characterize the profiles from top to bottom, nor are there any systematic changes between the fragipan pedons and non-fragipan pedons. Within the fragipan horizons, however, two systematic changes occur downward: (1) there is a general increase in kaolinite and (2) there is a general decrease of regular interstratified illite-montmorillonite. We interpret the overall lack of systematic variability as an indication of soil deterioration.

Nold, J. L. and Dudley, M., Department of Earth Science, Central Missouri State University, Warrensburg, MO 64093. ORE PETROLOGY OF THE BIG EIGHT—SNOWSTORM MINES, LINCOLN CO., MONTANA. The Big Eight and Snowstorm properties west of Troy, Montana, were mined sporadically for lead-zinc-copper-gold-silver ore from approximately 1917 to 1931. The mines were developed on a northwest-striking, steeply dipping vein, partly replacing a parallel dioritic dike. The host rock for the vein and dike is a series of gently dipping argillites, siltites and quartzites from the Prichard Formation which is part of the Belt Supergroup of Proterozoic age. The most abundant metallic minerals in the vein are sphalerite, galena, pyrrothite, pyrite, chalcopyrite, magnetite and arsenopyrite. The most abundant gangue minerals are quartz, calcite, actinolite, chlorite, and garnet. The Big Eight-Snowstorm mines are unusual in possessing the overall character of a vein and the mineral assemblage of a skarn. The Big Eight-Snowstorm mines are of interest to modern-day explorationists because they represent the fourth largest concentration of lead-zinc-silver ores within the Belt Supergroup. The two largest lead-zinc-silver concentrations in Beltian age rocks are the Sullivan Mine, B. C., a world-class stratiform orebody in the Prichard Formation, and the Coeur d'Alene District, Idaho, one of the largest lead-zinc-silver vein districts in the world.

Jacquess, J. C. and Hagni, R. D., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. MINERAL DEPOSITION IN HOT WATER PIPES AT HOT SPRINGS, ARKANSAS. Pipes for the collection, cooling and distribution of hot water for consumption and bathing at Hot Springs, Arkansas contain mineral deposits that progressively constrict the flow of hot water. These deposits have been studied by petrographic, ore microscopic, x-ray and microbeam techniques. The principal mineral, calcite, is thickest in the collection pipes versus distribution pipes and exhibits a banded sequence composed of 12 or more bands. These bands are distinguishable by differences in grain size, iron staining and by orange cathodoluminescence. Calcite in surface tufa deposits is not cathodoluminescent, in contrast to calcite which lines the collection pipes. Manganese and iron oxides and hydroxides occur as local grains and as late, massive colloform coatings in some pipe deposits and in tufa at some springs. This research has been supported by Arkansas Geological Commission and the Hot Springs National Park Service.

Netzler, B. W., Missouri Department of Natural Resources, Division of Geology and Land Survey, Geological Survey Program, Rolla, MO 65401. DISCOVERY AND DEVELOPMENT OF RUNAMUCK OIL FIELD, ATCHISON COUNTY, MISSOURI. The field is located 12 miles southwest of Tarkio, Missouri on the Atchison-Holt County line near the town of Corning. The oil field is 1 mile long by $\frac{3}{4}$ mile wide and is developed on a northward plunging anticline (that trends north-south) which is fault bounded on the southeast and south. At the end of 1987 six wells were producing oil from Ordovician Kimmiswick (Viola) dolostones at approximately 2800 feet. Cumulative production for 1987 is approximately 25,000 bbls of oil and 17,000 bbls of water. The field is an active water drive with all wells being on pump. The best well had an initial production of 125 bbls/day but quickly dropped. Average production is 25-30 bbls/day/well. The Runamuck Oil Field was discovered in the spring of 1987 by James K. Anderson, Inc. of Dallas, TX. There are three operators in the field: James K. Anderson, Inc., Stone Petroleum Corp., and Coastal Oil and Gas Corp. This discovery reemphasizes the significant potential that exists in northern Missouri for Paleozoic discoveries.

Lee, J. T., Chiou, K. Y., and Manuel, O. K., University of Missouri-Rolla. DOUBLE BETA DECAY OF TELLURIUM-128 AND TELLURIUM-130. The isotopic compositions of xenon in the mineral altaite, PbTe, from the Mattagami Lake area of Quebec, were measured to determine the amounts of radiogenic ^{128}Xe and ^{130}Xe produced by double-beta decay of ^{128}Te and ^{130}Te , respectively. We have repeated these geochemical measurements of $\beta\beta$ -decay by stepwise heating. From the results, we concluded that the ratio of the $\beta\beta$ -decay half-lives, $T_{1/2}^{128}/T_{1/2}^{130}$ is about 2600 and the values of $T_{1/2}^{128}$ is 1.8×10^{24} y. Lepton number violation is not required by these results.

Walck, C. M. and Hagni, R. D., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. ORE MICROSCOPIC STUDY OF A SHALE-HOSTED SULFIDE DEPOSIT IN THE WESTERN U.S. An ore microscopic examination of polished sections prepared from drill core from a copper sulfide deposit was undertaken to determine the mineralogy, ore textures, and paragenetic sequence. The deposit is a slightly metamorphosed, shale hosted, disseminated to massive sulfide deposit, similar in texture, but not in mineralogy to the Red Dog, Lik, and Su deposits in Alaska. The most prominent feature of the ore is the banding which is conformable with the hostrock bedding. Pyrite, the earliest and most abundant mineral, exhibits subhedral, coliform, framboidal, and rounded shapes. Chalcopyrite, the second most abundant mineral, fills porous voids and replaces pyrite. Sphalerite, tennantite-freibergite, covellite, bornite and digenite are also present in lesser amounts. This sulfide deposit is an example of a shale-hosted stratiform deposit, formed on the seafloor, in which the sulfides were deposited early in the diagenetic history of the enclosing sediments.

Ku, J. W. and Rupert, G. B., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. OPTIMUM FOLD FACTOR IN SEISMIC VELOCITY ANALYSIS. The common mid point (CMP) method is routinely used to improve the signal to noise ratio in seismic exploration and data processing, and more recently used to estimate lithology and fluid content. By means of velocity analysis, a series of stacking velocities are obtained, normal move out (NMO) is applied and the CMP gather traces summed into one final trace. However, many factors affect the results of velocity analysis; for example, the window length, the window overlap length, and fold are all parameters to be considered. This study concentrated on semblance as a function of the fold and to determine the optimum number of fold for obtaining high accuracy velocities. Synthetic seismic CMP trace models were used for the study. It is concluded that folds must be used along the time axis of any one trace. For deep targets, an increase in fold results in an increase of semblance, but for the shallow events, a reduction in fold results in an increase of semblance. Some results are also shown for real seismic data.

Hatfield, S. C. and Grant, S. K., Department of Geology & Geophysics, University of Missouri-Rolla, Rolla, MO 65401. MINERALOGY AND CHEMISTRY OF THE TUFF OF PRITCHARDS STATION, EAST-CENTRAL NEVADA. The Tuff of Pritchards Station (TPS) in east-central Nevada is a little known ash-flow tuff of limited areal extent. A detailed study of this tuff was conducted to determine if it is a distinctive unit which can be correlated from one locality to another. Mineralogical and chemical data indicate that the TPS displays significant lateral variability. Lateral variations in mineralogy include changes in total crystal content and the amount and grain size of individual minerals present over the area studied. Also, certain elements, most notably titanium, show considerable lateral variation as well. No vertical variation or zonation was observed at the studied localities of the TPS. The reasons for the lateral variability in the Tuff of Pritchards Station are not known. Some possible explanations are: the lateral variations are actually due to vertical variations, multiple eruptions from a single magma chamber, lateral sorting during eruption and emplacement of the tuff, and miscorrelation of units.

Mavrogenes, J. A. and Hagni, R. D., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401; **Dingess, P. R.,** ASARCO, West Fork, P.O. Box 116, Bunker, MO 63629. MINERALOGY, PARAGENETIC SEQUENCE, AND MINERAL ZONING OF THE WEST FORK MINE, VIBURNUM TREND, SOUTHEAST MISSOURI. An ore microscopic study has been initiated to determine mineralogy and paragenetic sequence in selected samples from the West Fork mine (Viburnum Trend, southeast Missouri) to correlate microscopic observations with mineral zoning determined by underground mapping at the mine. The ore deposit at West Fork is especially well zoned and differs from other deposits in the district by the presence of unusually light colored, very fine-grained collomorphic sphalerite. The general paragenetic sequence is dolomite, fine-grained disseminated and framboidal pyrite, sphalerite, collomorphic pyrite and marcasite, bravoite, galena, and late marcasite. These data may aid in the prediction of the margins of the orebody.

Nold, J. L., Department of Earth Science, Central Missouri State University, Warrensburg, MO 64093. THE PILOT KNOB HEMATITE DEPOSIT—A VOLCANO-SEDIMENTARY IRON DEPOSIT. The Pilot Knob hematite deposit in Iron County, Missouri, exhibits two basic types of hematite occurrence. These include, 1) fine-grained, laminated, banded-iron-formation, and, 2) coarse-grained rhyolite breccia containing minor fine-grained hematite and pyroclastic fragments of high-grade hematite. The banded-iron-formation exhibits abundant evidence of sedimentary deposition, including ripple marks, mud cracks, and continuous, thin laminae. In the rhyolite breccias overlying the banded ores, the high-grade hematite fragments prove the existence of primary hematite near a vent complex during rhyolitic volcanism. Replacement textures are present in the ores and have been cited by numerous authors as evidence of epigenetic origin of the deposit. However, replacement occurs only on a very small scale and is probably no more than expected from minor remobilization of primary minerals in any ore deposit. The fine-grained, banded ores of the Pilot Knob hematite body were apparently deposited in a shallow sedimentary environment and were perhaps the result of venting of iron-bearing solutions emanating from the underlying Pilot Knob igneous-hydrothermal magnetite deposit.

Hathon, L. A., Department of Geology, University of Missouri, Columbia, MO 65211. THERMAL MATURITY OF MIDDLE PENNSYLVANIAN STRATA, ARKOMA BASIN. The thermal maturity of exposed Middle Pennsylvanian strata in the Arkoma Basin is high. Vitrinite reflectance (Ro) increases from 0.7% to 2.0% from west to east across the basin. Ro levels of Atokan strata in the subsurface indicate that the basin is not in thermal equilibrium with the present-day temperature regime. Estimated maximum paleotemperatures are significantly higher than measured subsurface temperatures. Ro-depth profiles have similar shapes and slopes throughout the basin, exhibiting a dog-leg which may be associated with a change in dominant lithology within the Atoka and with the development of paleogeopressures. Subsurface Ro increases systematically from 1.8% to nearly 4.0% from west to east. This increase is directly opposed to gradients in maximum sedimentary and tectonic burial, indicating that neither of these was the major control on the thermal maturity of Arkoma Basin Middle Pennsylvanian strata. Locally, paleotemperature distributions parallel major fault trends. Syndepositional normal faults may have acted as heat sources, and as conduits for hydrothermal discharge from the Ouachita orogenic belt.

Mantei, E. J., Department of Geosciences and **Foster, M.**, Department of Computer Science, Southwest Missouri State University, Springfield, MO. POSSIBLE DIRECTIONS OF ORE FLUID MOVEMENT ASSOCIATED WITH THE SE MO ORE DEPOSITS. Decreasing trends of certain trace metal quantities in ore minerals within an ore body may indicate directional movement of ore solutions. The Sb and Ag content was obtained for 182 galena cubic habit samples collected from six mines in the Viburnum Trend and from the Indian Creek Mine of SE MO. These samples are from four stratigraphic ore zones within the Cambrian Bonnetterre Formation. The mean content of Sb and the mean Sb/Ag ratio in the samples show a consistent decreasing horizontal trend in two of the stratigraphic ore zones northward and southward from the mine locations in the central Viburnum Trend area. Also, there appears to be a decreasing trend of these two values in the samples from the lower to the higher ore zones. These trends may represent ore fluid depletion of the Sb during the formation of the galena cube form as well as indicating the directional movement of the ore fluids which formed the galena cubes. No such horizontal or vertical trend is evident with the mean Ag content.

Hildebrandt, M. E. and Grant, S. K., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401; **White, J. M.**, Rock Mechanics and Explosives Research Center, University of Missouri-Rolla, Rolla, MO 65401. A STUDY OF DEFORMATION AND FRACTURING IN LARGE CRYSTALS PRODUCED BY A WATERJET. In this study, large crystals of calcite and quartz were cut by a waterjet and then were examined for deformation and fracturing structures in order to better understand the detailed mechanisms by which the waterjet cuts. The jetted rocks were prepared into petrographic slides to attempt to find deformation and fracturing. These were observed to be related to the properties of the mineral, the direction of the jet force, and the presence or absence of abrasive.

Interdisciplinary Poster

Rushin, J. W., Missouri Western State College, St. Joseph, MO 64507; **Green, R.**, Missouri Department of Conservation, Jefferson City, MO 65101. TEACHING CONSERVATION THROUGH THE OUTDOOR CLASSROOM. This is an in-service summer short course primarily for elementary teachers. It has been conducted at Missouri Western State College during the past 5 summers and has involved 110 local teachers. The essential goals of the short course were to help teachers gain a better understanding of the outdoor classroom and how the interdisciplinary approach to conservation education can be used effectively in the teaching of science-related topics. A summary of how the goals and objectives were met is included. There is also a summary of course evaluations and teacher characteristics based on a survey of the participants. In addition, examples of student projects and some of the science-related conservation teaching materials will be included.

Robbins, D. J. and Ashley, D. C., Biology Department, Missouri Western State College, St. Joseph, MO 64507; **Bell, R. L. and Bell, T.**, Squaw Creek National Wildlife Refuge, Mound City, MO 64470. A REPORT OF MORPHOMETRIC DATA ON WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) COLLECTED DURING THE FIRST SQUAW CREEK REFUGE PRIMITIVE WEAPONS HUNT. Fifty-five intact hunter-killed deer harvested from Squaw Creek Refuge in January, 1988, were sexed, aged, weighed, and measured. The kidney fat index was calculated for each deer. The mean total length for does was 178 cm (132-207 cm) and 184 for bucks (154-207 cm). The mean tail length in does was 26 cm (18-33 cm) and 27 cm in bucks (19-32 cm). The mean whole weight in does was 166 lbs (60-170 lbs) and 186 lbs in bucks (90-247 lbs). The mean dressed weight for does was 130 lbs (45-130 lbs) and 146 lbs for bucks (65-190 lbs). The mean kidney fat index for does was 189% (15-909%) and 127% for bucks (15-366%).

Gronefeld, D., Broyles, D., and Conrad, M. L., Northeast Missouri State University, Kirksville, MO 63501. STUDY OF A NATIVE PRAIRIE IN SULLIVAN COUNTY, MISSOURI. Recently in the midwest there has been a growing interest in grassland management. Less than one percent of the once vast habitat is undisturbed. One such prairie exists on the James Broyles farm. This nine acre tract is the largest known native prairie in northeast Missouri. A plant list of over 100 species has been compiled including the characteristic species of *Andropogon gerardi*, *A. scoparius*, *Sorghastrum nutans*, *Amorpha canescens*, *Gentiana clausa*, *G. puberula*, *Eryngium yuccifolium*, *Liatris pycnostachya*, *Petalostemon candidum*, and *P. purpureum*. Preliminary soil analysis revealed

an A-horizon of 9 to 16 inches. Soil pH was measured moderately acid, and organic matter was 5.7%. Expressed in lbs./acre, $P_2O_5 = 56$, $K_2O = 135$, $Ca = 3050$ and $Mg = 340$.

Guyette, R., McGinnes, E. A., Jr., and Cutter, B., University of Missouri-Columbia, 1-31 Agriculture Building, Columbia, MO 65211. PAST CHANGES IN SOIL pH ARE RECONSTRUCTED FROM THE ELEMENT CONCENTRATIONS IN GROWTH INCREMENTS OF EASTERN REDCEDAR (*JUNIPERUS VIRGINIANA*). Past changes in soil pH were estimated from the concentrations of elements in growth increments of eastern redcedar. Concentrations of Sr, Ba, Mg, Al, B, Mn and Zn in wood were correlated with site soil pH (3.1 to 7.9) for 59 trees. Correlation coefficients for soil pH variables and element concentrations ranged from -0.85 for $\log[Ba]$ to -0.39 for B. Calibration regressions were developed using these spatial data to explain from 52% to 82% of the soil pH variation on the tree sites. These spatially derived regression models were then evaluated and used to estimate temporal changes in soil pH from element chronologies of redcedar heartwood 200 to 700 years in length. Changes in soil pH in the range of 0.5 units were found coincident with periods of acidic deposition. Research was funded by the USDA.

Guyette, R., McGinnes, E. A., Jr., and Cutter, B., University of Missouri-Columbia, 1-31 Agriculture Building, Columbia, MO 65211. POLLUTION HISTORY FROM ELEMENT CHRONOLOGIES DERIVED FROM GROWTH INCREMENTS OF EASTERN REDCEDAR (*JUNIPERUS VIRGINIANA*). Element chronologies from growth increments of eastern redcedar were used as a measure of change in atmospheric trace element deposition. Old trees were sampled on acid and basic soils in industrial and nonindustrial areas. Over 900 samples of wood were analyzed for the presence and concentration of 41 elements. Element concentrations in 20-year increments of wood were combined into element chronologies from 200 to 700 years in length. Past changes in Pb, Cd, Ca, Sr, Ba and Mg concentration in growth increments coincided with changes in land use and industrial activities. In the lead mining district of Missouri Pb concentrations in wood increased on sites with acid soils from $<.4$ ug/g before 1760 to 3.1 ug/g after 1960. Calcium concentrations peaked around 1860. Barium, Sr and Mg concentrations decreased after 1900 in trees growing on acidic sites in industrial areas. Research was funded by the USDA.

Carrel, J. E., McCormick, J. P., and Doom, J. P., Division of Biological Sciences and Department of Chemistry, University of Missouri-Columbia, Columbia, MO 65211. ORIGIN OF OXYGEN ATOMS IN CANTHARIDIN BIOSYNTHESIZED BY BLISTER BEETLES. Biosynthesis of cantharidin, a highly toxic defensive compound in meloid beetles, proceeds by the unprecedented degradation of farnesol. To learn more about this transformation, we examined the origin of the four oxygen atoms in cantharidin. Labeling studies used adult male beetles (*Epicauta pestifera*) exposed to the stable isotope O-18 either as oxygen gas or as water. Mass spectral data revealed that the tetrahydrofuran oxygen atom and two but not three of the anhydride atoms are derived from oxygen gas, whereas the third anhydride oxygen atom comes from water. Mass spectrometry of maximally labeled cantharidin showed that the water-derived oxygen atom is located in the anhydride ring in some molecules and in a carbonyl group in others, implicating intramolecular oxygen scrambling. Our results suggest that cantharidin may be a metabolite of juvenile hormone in blister beetles. Metabolic studies using radiolabeled juvenile hormone III are underway in our laboratory to test this idea. Supported by NIH grants AM 31186 and RR 0753.

Tablor, R. L. and Cain, C. R., Department of Agriculture, Central Missouri State University, Warrensburg, MO 64093. EVALUATION OF METRIBUZIN AND ACIFLUORFEN PHYTOTOXICITY ON SOYBEAN YIELDS. Metribuzin was preplant incorporated (PPI) at .43, .56, .84 and 1.12 kg active ingredient per hectare (kg ai/h). Alachlor was applied at 2.5 kg ai/h in tank-mix combinations with metribuzin and as a PPI treatment on aciflourfen plots and alachlor check plots to eliminate grass weeds. Aciflourfen treatments were applied at .56, .84 and 1.2 kg ai/h at the one to two trifoliolate leaf stage. Treatments were replicated nine times in a latin square design. Herbicide phytotoxicity evaluations were made as visual percent damage and percent stand thinning. Within two weeks after phytotoxicity evaluations were made, all soybean plants in the metribuzin plots had recovered and no stand thinning had occurred. Within four weeks after damage evaluations were made, all plants affected by aciflourfen had recovered. Alachlor had no visible effects on soybean plants in the alachlor checks. Statistical analysis showed no significant difference among treatments or checks.

Arne, C. N. and Bailey, W. C., Department of Entomology, University of Missouri-Columbia, Columbia, MO 65211. 1987 ALFALFA WEEVIL (AW) AND POTATO LEAFHOPPER (PLH) INSECTICIDE TRIALS ON ALFALFA. The AW and the PLH are two of the most destructive pests on alfalfa in the state of Missouri. Trials were undertaken to evaluate the effectiveness of several compounds on these pests. Selected concentrations of insecticides were applied in a random complete block design with four replications. Effectiveness of each was measured at 3, 7, 14, 21, and 28-days posttreatment. DMRT was used to determine the significance between insecticides at the 5% level. Compounds used included Asana, Capture, Furan, Larvin, Lorsban and Pounce. Through 21-days posttreatment all treatments had significantly lower numbers of AW than untreated control plots. Control at 28-days was variable. For PLH, all insecticides produced satisfactory control at day 3, but variable control thereafter.

Voorhees, F. R., Tavakoli, M., and Flagor, L., Department of Biology, Central Missouri State University, Warrensburg, MO 64093. ADDITIONS TO THE MOSQUITOES (Diptera: Culicidae) OF MISSOURI. Fifty-four species in nine genera of mosquitoes were recorded from Missouri prior to 1968. Subsequent published records and examination of unidentified specimens at the University of Missouri-Columbia resulted in the addition of five species, bringing the total to fifty-nine species in nine genera.

Oncology

Reynolds, R. D., Winston, J., and Gams, R. A., Department of Clinical Development-Oncology, Adria Laboratories, Columbus, OH 43216. BISOXOPIPERAZINE[(\pm) - 1,2 BIS (3,5-DIOXOPIPERAZINYL-1YL) PROPANE] (NSC-169780, ADR-529, ICRF-187) As a cardioprotective agent against NSC-123127 and other anthracyclines. Bisoxopiperazine is a potent intracellular chelating agent which appears to reduce the formation of iron anthracycline complexes which are responsible for producing free radicals responsible for producing cellular damage and by preventing oxygen radical formation. The compound has successfully reduced anthracycline induced cardiomyopathy in each mammalian species thus far tested. Dose and timing appear to be critical in this protective mechanism. One human trial has been completed and two additional trials are currently in progress. The published trial (M. Green et al., Proc. ASCO 6:28, 1987) demonstrated significant cardio-protection in breast cancer patients treated with standard Doxorubicin, Fluorouracil and Cyclophosphamide. This protective effect was accomplished without loss of efficacy or an increase in non-cardiac toxicity.

Shih, J. A. and Brugger, R. M., Department of Nuclear Engineering, University of Missouri-Columbia, Columbia, MO 65211. Neutron capture therapy (NCT) has been under development for 25 years, and some recent encouraging results indicate that it may become an effective therapeutic method for certain types of cancer. The major development thrusts are aimed at using ^{10}B as an agent, but an alternative agent might be ^{157}Gd . Two advantages of ^{157}Gd make it a good candidate to evaluate as an NCT agent. These are (1) ^{157}Gd has the highest thermal neutron capture cross section of stable nuclides, and (2) development of Gd compounds for use as Magnetic Resonance Imaging contrast agents are being made which may lead to concentration of ^{157}Gd in tumors. Gadolinium NCT utilizes the γ 's released from this to the tumor and to the surrounding healthy tissue are being made, and these are being compared to the results of B-NCT (an α source) and ^{131}I (a β dominant source). The preliminary calculations show that with reasonable parameters, Gd-NCT can deliver a large dose to a tumor with fair tumor to tissue advantage. Although the dose distribution is not as good as B-NCT, or ^{131}I , the total therapeutic effect may still be acceptable.

Physics

Northrip, J. W., Department of Physics and Astronomy, Southwest Missouri State University, Springfield, MO 65804. EMPHASIS ON INFORMATION CONCEPTS IN THE BASIC PHYSICS CURRICULUM. Historically, basic physics has been taught with emphasis on the interactions involving transfers of mass and energy in a space/time continuum. Modern technology is increasingly reliant on the understanding of information acquisition, encoding, processing, communication, and use in control and strategy design. The close relation of information theory to quantum and statistical physics makes an early introduction valuable to understanding intermediate and advanced coursework. The role of information concepts in such areas as instrumentation, system description, microphysics, second law applications, and modern optics will be discussed and exemplified.

Anderson, R. A., Department of Physics, University of Missouri-Rolla, Rolla, MO 65401. COHERENT DOPPLER LIDAR RESEARCH AT NASA GEORGE C. MARSHALL SPACE FLIGHT CENTER. This paper will present via slides a description of the many atmospheric research projects performed by NASA. These include studies on clear air turbulence CAT, severe storm research, and wind shear at airports. Finally, future research as part of the "Understanding Planet Earth" project will be discussed. These projects are shuttle, satellite, and space station based.

Stacey, L. M. and Gammel, J. L., Physics Department, St. Louis University, St. Louis, MO 63103. A NUMERICAL ALGORITHM FOR SOLAR SYSTEM SIMULATION. We have developed a numerical scheme for integrating the equations of motion of the solar system, including the nine planets, the moon, and five asteroids. The calculations include the general relativistic effects of the sun. The code simulates the passage of time at the rate of 1 century (cy) of actual time per about two hours of processor time on a Honeywell DPS-849 mainframe computer. We believe that errors from all sources accumulate at the rate of about 300 km/cy for the moon, 75 km/cy for Mercury, and 1 km/cy for the earth. Errors for the outer planets seem to be much larger, possibly because of failure to include enough asteroids in the model.

Kapoor, Y. M., Department of Natural Sciences and Mathematics, Lincoln University, Jefferson City, MO 65101. **Chandrasekhar, H. R., Chandrasekhar, M., and Kangarlou, A.,** Department of Physics, University of Missouri-Columbia, Columbia, MO 65211. "HIGH PRESSURE STUDIES OF $\text{GaAs-Al}_x\text{Ga}_{1-x}\text{As}$ QUANTUM WELLS AT DIFFERENT TEMPERATURES USING PHOTOREFLECTANCE SPECTROSCOPY". The effect of hydrostatic pressure and temperature on the transitions in a $\text{GaAs-Al}_{0.3}\text{Ga}_{0.7}\text{As}$ multiple quantum well of well width 260Å is carried out using the photoreflectance technique. The pressure dependence of a large number of quantized states is observed. Model calculations, in which the material parameters are included, give a satisfactory fit to the observed data. It is observed that the change in the electron effective mass with pressure leads to a substantial sub-linear pressure dependence of the quantum well transitions. This effect is large for higher energy states. Indirect transitions associated with L and X band extrema are observed and their pressure coefficients deduced. The exciton binding energy of the lowest excitonic transition is found to increase until $\Gamma - \times$ crossover and decrease at higher pressure.

Raffaelle, R. and Sparlin, D. M., Department of Physics, University of Missouri-Rolla, Rolla, MO 65401. APPLIED PHYSICS AND CERAMICS ENGINEERING. The fabrication of perovskite conductive material is important to every application requiring high temperature conductors. The conduction mechanisms in these materials can be drastically altered by defect states. These states can be characterized using a transient spectroscopy based on either conduction or capacitance. Optical pumping is used for very resistive samples. Capacitance measurements were attempted across grain boundaries to characterize the defect state influence upon frequency response in grain boundary limited oxide conductors.

Sparlin, D. M., University of Missouri-Rolla, MATHCad, SUPER STUDENT SOFTWARE. The student version of MATHCad is available at a cost of \$34.95. This software provides a nearly ideal tool for the preparation of examinations, lecture notes, and especially student lab reports and homework assignments. I am using this software to prepare supplemental class notes, and to annotate and supplement the solutions manual. The students are currently using MATHCad to pursue extra credit assignments. This program will be demonstrated.

Science Education

Babrakzai, N., Kimberlin, T., and Wiskur, D., Department of Biology, Central Missouri State University, Warrensburg, MO 64093. DEVELOPMENT OF COMPUTER ASSISTED ANIMATION MEDIA IN BIOLOGICAL SCIENCES. This project is designed to develop computer assisted animation media to communicate sophisticated biological concepts to the students. The animation effect is achieved by planning 100-1000 sequential drawings, each with subtle differences to give the desired effect. Each planned drawing is constructed on the computer screen with the help of appropriate software (e.g. PaintworksPlus) and stored in a disc medium. Then all the picture screens are compressed, and sequentially projected on a computer screen by means of menu driven software. Fast projection of sequential drawings will visually give the desired animation effect of a biological phenomenon or concept. The animation can be saved on an 800k 3½" diskette. Hard copies of any picture screen can be printed both in color and or B/W by means of a dot matrix printer. Longer "animation shows" can be recorded on a video tape or a SCSI hard disc.

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Barrow, L. H., Department of Curriculum and Instruction, University of Missouri-Columbia, Columbia, MO 65211. STATUS OF PRESERVICE ELEMENTARY SCIENCE IN THE BIG EIGHT STATES. The study of 132 higher education institutions concerning the way that they prepare K-6 teachers to teach science. There was a 96.9% return rate of the mailed survey to Deans/department chairs of education. Each respondent reacted to how their preservice program was meeting the National Science Teachers Association guidelines (1983). Major findings were: only 13% of the institutions require their elementary education majors to have biological, earth, and physical science content courses, 90%+ require an elementary science methods course, state guidelines have major influence in determining the program, and gave their program in a positive overall rating. Supported by University of Missouri Faculty Research Council.

Cameron, P. J., Department of Biomedical Sciences, Southwest Missouri State University, Springfield, MO 65804. DEVELOPMENT OF AN INTRODUCTORY LEVEL METHODS AND INSTRUMENTATION COURSE. Science students in upper division laboratory courses often lack basic laboratory skills. Lower division courses stressing information and content allow little time for the development of these skills. To better prepare our students, an introductory methods and instrumentation course, BMS 222, was initiated. After surveying ten instructors with broad laboratory expertise, a list of basic skills common to a number of courses was compiled. By removing specific course related material, a series of laboratory experiences was developed which allows each student to concentrate on skills acquisition. Verbal feedback from past students and test analysis indicates the following: 1) Deficiencies are common; 2) Students acquire these skills given time and opportunity; 3) The removal of specific course content does not adversely affect the mastery of these skills. Further studies are in progress to measure the retention and continued development of these skills as students continue throughout their science program.

Gordon, A. R. and Mortensen, H. E., Department of Biomedical Sciences, Southwest Missouri State University, Springfield, MO 65804. AN ALTERNATE BIOLOGICAL CURRICULUM AT SOUTHWEST MISSOURI STATE UNIVERSITY. The success of the cell-molecular approach in addressing biological problems places greater demands on the relevance of biological curricula. There is little room in a classical curriculum for the required shifts in emphasis from the evolutionary theme that focuses on the diversity of organisms to one that stresses the unity of life structure and function. This presentation shall describe the new Department of Biomedical Sciences which was established at Southwest Missouri State University. The curriculum is based on the approach of cell-molecular biology and uses the human organism as the main focus of example. The concept- and skill-based curriculum of the new department provides students with a practical, efficient and alternate emphasis of biological study.

Newman, B. K. and Gordon, A. R., Department of Biomedical Sciences, Southwest Missouri State University, Springfield, MO 65804. A CONCEPTS- AND SKILL-BASED INTRODUCTORY BIOLOGY COURSE AT SOUTHWEST MISSOURI STATE UNIVERSITY. Introductory biology courses may be organized around different

themes and emphases. The curriculum of the new Department of Biomedical Sciences is based on a cell-molecular approach that uses the human organism as an example. BMS 110, Concepts in the Biomedical Sciences, was developed to satisfy the theme that stresses the commonality of life processes rather than the distinctness of living organisms. The lecture focuses on the presentation of the major concepts in biology. Laboratory exercises reinforce the lecture and introduce the tools and techniques of a practical and skill-based curriculum. The organization of the course will be discussed and the results of three years of experience will be related.

Northrip, J. W., Department of Physics and Astronomy, Southwest Missouri State University, Springfield, MO 65804. TOPICS IN SCIENCE AND MATHEMATICS FOR ENRICHMENT UNITS IN GIFTED STUDENT PROGRAMS. Programs involving high performance students show a wide range of strategies for obtaining optimum learning in the areas of mathematics and science. One option is to choose areas seldom included in any standard curriculum, but which introduce diverse techniques of acquiring, encoding, and manipulating information. Even though these may have little formal use during the standard educational process, they leave viewpoints and logical techniques which may aid in conceptualizing new problems, systems, and strategies. Examples will be given from areas of human motion, microphysics, intelligent life search, analysis of logic, and multidimensional geometry.

Scism, A. J., Department of Chemistry, Central Missouri State University, Warrensburg, MO 64093. CURRENT TOPICS REPORTS IN BIOCHEMISTRY: A MULTI-FACETED TEACHING TOOL. I have recently required the discussion of current topics in my biochemistry class. Topics are selected by the students from stimulation provided by news media or other non-technical sources. Students are required to prepare a brief (1-3 pages) paper, a one-paragraph abstract of the paper and to give a brief (5-15 minute) oral report on their topic. The number of topics required of each student can be variable, depending on class size and other factors. Topic discussions may involve review of covered class material or serve as preview of material yet to be discussed. Writing and speaking skills are enhanced and students get some exposure to the technical literature as they search for background and supplementary material. Overall, student response to the Current Topics Reports has been favorable.

Scism, A. J., Department of Chemistry, Central Missouri State University, Warrensburg, MO 64093. AN INTERDISCIPLINARY WORKSHOP FOR JUNIOR HIGH SCHOOL SCIENCE TEACHERS. An eight-day summer workshop at CMSU provided instruction and hands-on experience in chemistry, physics, earth science and biology. Many workshop activities focused on Core Competencies and Key Skills developed for science in grade levels six through nine. Use of computers for assisted learning, data gathering and treatment was also emphasized. Much of the equipment and materials used was given to the teachers for use in their classrooms. Following the workshop, participating teachers developed projects involving their own students. The projects involved methods, ideas, and materials introduced at the workshop. Workshop staff visited participating teachers at their schools for follow-up help and support with their projects. A Report/Sharing Day was held at CMSU in November at which the teachers shared their classroom projects. Graduate credit was awarded those teachers who successfully completed projects and other requirements. Supported by Education for Economic Security funds awarded by the Missouri Coordinating Board for Higher Education.

Berkland, T. R. and Cocke, J. M., Department of Earth Science, Central Missouri State University, Warrensburg, MO 64093. FIELD STUDY IN MINERALS AND ROCKS FOR KINDERGARTEN AND FIRST GRADERS. In this study, six mineral and six rock specimens were examined by kindergarten and first grade students prior to a field excursion into a state park. Selected specimens exhibited characteristics of those particular rocks or minerals found at the site. After the "hands-on" examination of the sets, each specimen was identified by the teacher. The students then examined rocks and minerals in the park. They observed that the most common rock in the park was limestone but also found drusy quartz crystals, muscovite, chert, coal, shale, and sandstone. It was concluded that young people can benefit more from field trips if they learn examination techniques prior to the outdoor experience.

We regret that the following abstracts were inadvertently omitted from Vol. 21. We apologize.

The Editors

Pulse, D. L. and Geilker, C. D., Department of Electrical Engineering, University of Missouri-Columbia/Kansas City, Independence, MO 64050 and Department of Physics, William Jewell College, Liberty, MO 64068. **COMPUTER INTERFACEABLE WEATHER INSTRUMENTS FOR USE IN RESEARCH.** Precise weather data are needed in many research projects. Although the National Weather Service provides weather information for major installations such as airports the weather conditions can change drastically within a few miles. An accurate and affordable means of recording weather data on site is needed. The system presented measures wind speed, wind direction, and temperature digitally and provides the data in a byte form compatible with most computers. This allows for automated data acquisition or direct display. Hall Effect circuitry incorporated into the anemometer provides long life and increased reliability over other designs. A real time clock and applications for solar heating research will be discussed.

Nold, J. L., Department of Geology, Central Missouri State University, Warrensburg, MO 64093. **A NEED FOR GREATER PUBLIC AWARENESS OF THE GEOLOGICAL SCIENCES — WHAT CAN WE DO?** The role and the importance of the geoscientist within society is, in general, not well understood by the public. As geoscientists, we have a collective responsibility to educate the public in order to make geoscience better understood. One way this can be done is through the medium of television. In our department, we currently offer over CMSU's public television station, KMOS TV, a two semester hour lecture geology telecourse entitled Geology Fundamentals and New Concepts. This course is taken by 10 to 20 people per semester and is designed to reach public school teachers who want to raise their level of ability in the earth sciences. This type of program moves toward the goal of better public awareness of the geological sciences in the following ways: 1) by raising the level of ability of the teachers who may then disseminate the information to their students and, 2) by providing geological programming which is probably watched by many more people than those who enroll for credit. Another way in which the geosciences can be publicized is by articles in local newspapers on various earth science subjects.

