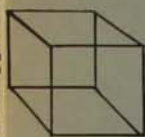


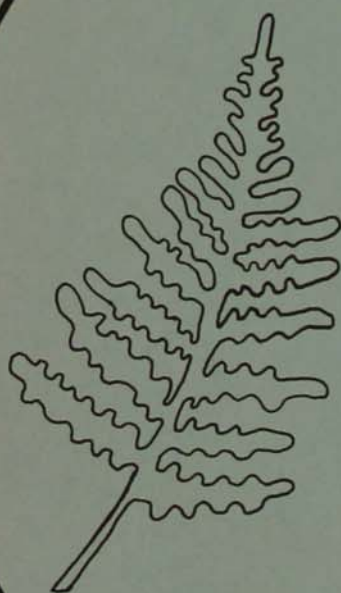
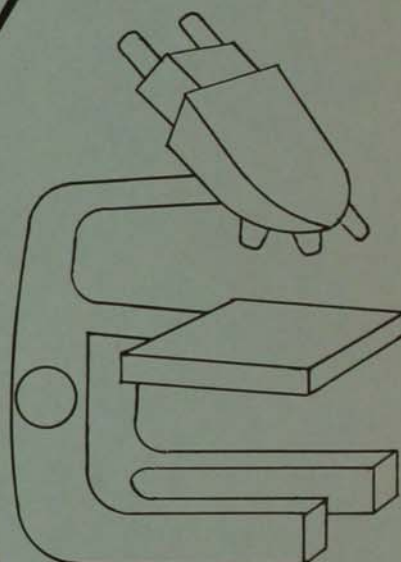
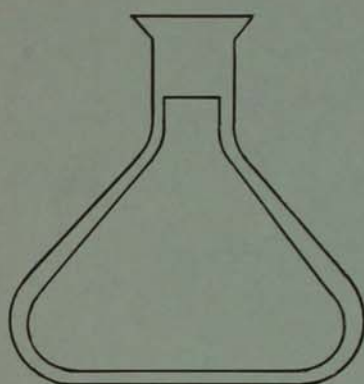
Vol. 44, No. 2

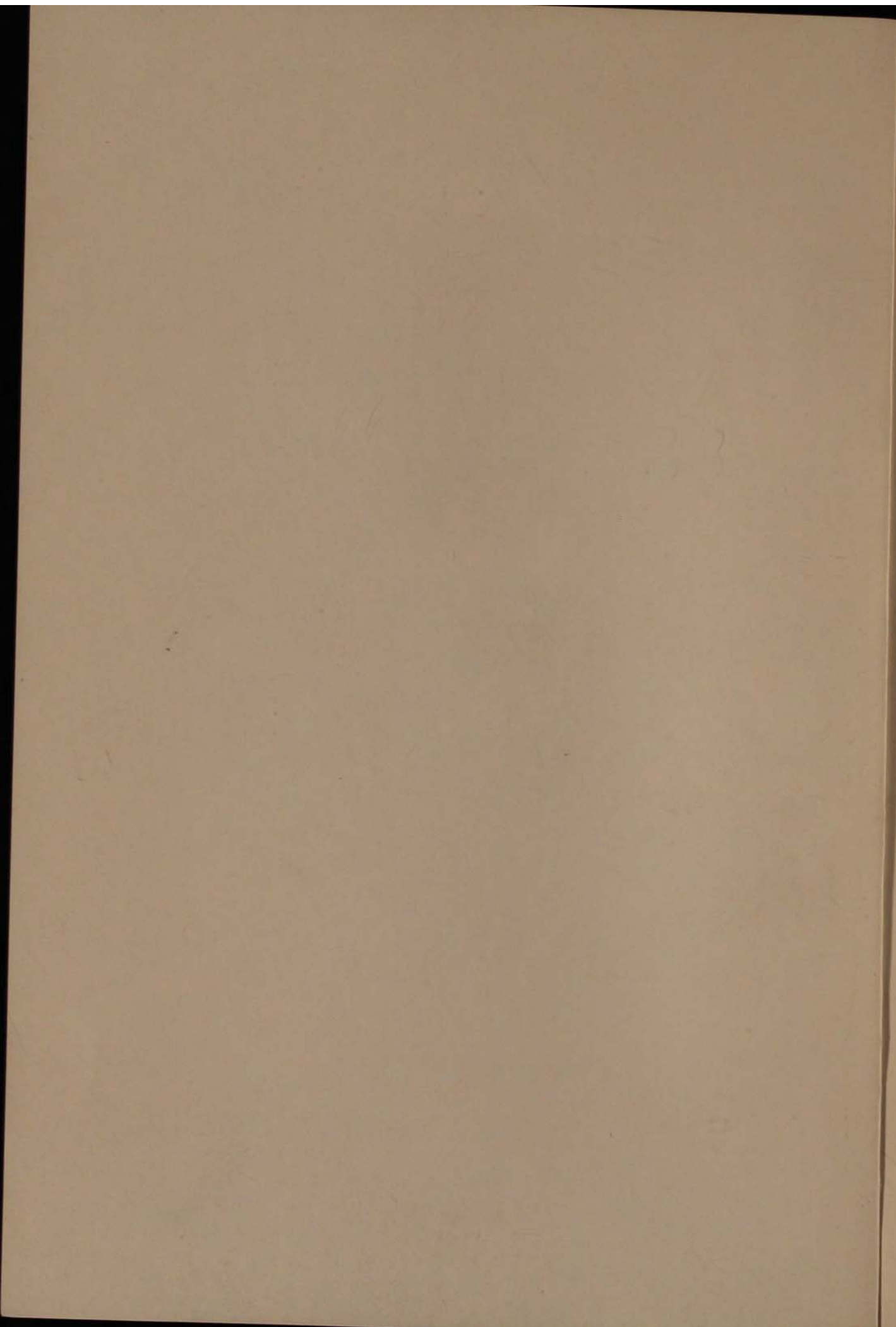
Proceedings of the West Virginia Academy of Science

1972



S^3







**Proceedings of the West Virginia
Academy of Science
1972**

Vol. 44—No. 2

THE FORTY-SEVENTH ANNUAL SESSION

Bluefield State College

Bluefield, West Virginia

APRIL 6, 7, 8, 1972

Printed by
McClain Printing Company
Parsons, West Virginia

West Virginia Academy of Science, Inc.

The West Virginia Academy of Science was founded at Morgantown, November 28, 1924. The Academy was incorporated under the Code of West Virginia on May 9, 1959 as "a nonstock corporation, which is not organized for profit but for the advancement of learning and scientific knowledge."

Proceedings of the West Virginia
Academy of Science

Editor

Anthony Winston

Section Editors

Virgil G. Lilly
Biology

Robert E. Adams
Biology

James L. Hall
Chemistry

John Grunninger
Chemistry

Harold V. Fairbanks
Engineering Sciences

Milton T. Heald
Geology

Arnold J. Levine
Mathematics and Physics

Robert L. Decker
Psychology and Education

Richard S. Little
Social Science

Elizabeth A. Bartholomew
Newsletter

Published biannually by the West Virginia Academy of Science, Inc. Manuscripts for publication should be sent to the Editor, Anthony Winston, Department of Chemistry, West Virginia University, Morgantown, West Virginia 26506. Proof, edited manuscripts, and all correspondence regarding papers for publication should be directed to the Editor.

Applications for membership in the Academy and dues should be sent to Joseph Glencoe, West Virginia Wesleyan College, Buckhannon, West Virginia 26201. Changes of address should be sent to Elizabeth Ann Bartholomew, Department of Biology, West Virginia University, Morgantown, West Virginia 26506. Correspondence concerning library exchanges should be directed to Director of Libraries, West Virginia University, Morgantown, West Virginia 26506.

The West Virginia Academy of Science and the Editors of the Proceedings of the West Virginia Academy of Science assume no responsibility for statements and opinions advanced by contributors.

Contents

CHEMISTRY SECTION

Thomas F. Lemke, Donna Borkowski, and Tulsi Sutaria, <i>NMR-Hammett Correlation of Anilino-fumarates</i>	125
B. A. Phillips, J. Gal, and G. Fodor, <i>The Mechanism of the von Braun Amide Degradation</i>	126
Thomas F. Lemke and Khizar Wasti, <i>Condensation Reactions of Diethyl Oxomalonate</i>	136
Carolyn M. Baltzer and C. Gordon McCarty, <i>The Synthesis of Cyclic N-Cyanoguanidines</i>	136
Denis W. H. MacDowell and James C. Wisowaty, <i>Some Thiophene Analogs of Anthraquinone</i>	138
Ron E. Linder and A. Campbell Ling, <i>Cavity-Molecule Isolation Techniques of the Structure of Radicals Produced by Gamma-Radiolysis</i>	139
T. E. Bitterwolf and A. Campbell Ling, <i>The Consequences and Significance of Protonating Ferrocene at the Metal</i>	141
James L. Hall, <i>Use of the Neutral Equivalent as an Aid in the Preparation and Characterization of Metal Ion Complexes of the Aminoalcohols</i>	142
S. Thomas Bond and Norman V. Duffy, <i>Mass Spectra and Bonding In Group VI Metal Pentacarbonyl Compounds</i>	145
S. Gurunathan and M. R. Chakrabarty, <i>A Study of Some Copper Complexes of N-methylamides</i>	146

GEOLOGY AND MINING SECTION

Benton M. Wilmoth, <i>Ground Water Development for Communities and Industries in West Virginia</i>	149
Mary G. Hill and John R. Sievers, <i>Lunar Orbital Positions and Earthquake Frequency</i>	155
John M. Dennison, <i>Uranium Potential of Mississippian Mauch Chunk-Pennington Groups in Virginias and Maryland</i>	160
Dilip C. Jain and Jesse J. Brown, Jr., <i>Use of Density Measurements to Study the Thermal Conversion of Kyanite to Mullite</i>	161

MATHEMATICS, PHYSICS AND ENGINEERING SCIENCES SECTION

H. V. Fairbanks, <i>A Hypothesis Regarding the Effect of Ultrasonics Upon Corrosion of Steel</i>	162
Ronald L. Huston, Alvin M. Strauss, and Stanton A. Glantz, <i>Analysis of Social Systems—An Application of Mechanics</i>	170
A. M. Strauss, <i>A Bilinear Functional Theory of Viscoplasticity</i>	183

James C. Goodwin II and Sunder H. Advani, <i>Lumbar Dynamic Response of Seat Belted Occupant to Automotive Impact</i>	190
Linda Z. Condry and Gerald E. Moore, <i>Sulfur Dioxide Regeneration From Modified Flyash</i>	199
James R. Stafford and Teng-Fang Li, <i>Nonlinear Deformation of a Curved Beam Having Cylindrical Anisotropy</i>	206
R. B. DeVore and W. E. Vehse, <i>Color Centers In CaF₂</i>	207

PSYCHOLOGY AND EDUCATION SECTION

J. M. Gaither, R. L. Decker, and J. D. Moore, <i>Some Social and Economic Value Orientations of Social Science Textbooks in West Virginia Public Schools</i>	208
Meir Teichman, Yona Teichman, and Uriel G. Foa, <i>A Comparison Between Neurotics' and Normals' Perceptions of Interpersonal Exchange in Family Roles</i>	214
Ronald N. Bone, <i>Introversion, Extraversion and Free Recall Learning</i>	218
Ronald N. Bone and Barbara B. Griswold, <i>Birth Order and Creativity</i>	221
Julia Ann Greenwood and George Ward II, <i>External Commitment Effect as a Function of Need for Social Approval</i>	224

SOCIAL SCIENCE SECTION

John R. Warner, Jr., Albin R. Gilbert, and Dana G. Cable, <i>Attitudes of White Students Toward Matters of Forced Integration, Personal Intimacy and General Principles of Equality</i>	228
Edward A. Johnson and Beryl A. Johnson, <i>The Influence of Company Size on the Goals and Activities of Personnel Managers</i>	231
Alvar L. Nieves and Meir Teichman, <i>A Consideration of Some Sociological Variables Associated With Attitudes Towards Women's Rights</i>	232
Paul Ridgely, <i>A Study of Attitudes Toward Poverty and Unemployment By Unionists and Managers</i>	236

37

Chemistry Section

NMR-Hammett Correlation of Anilino-fumarates

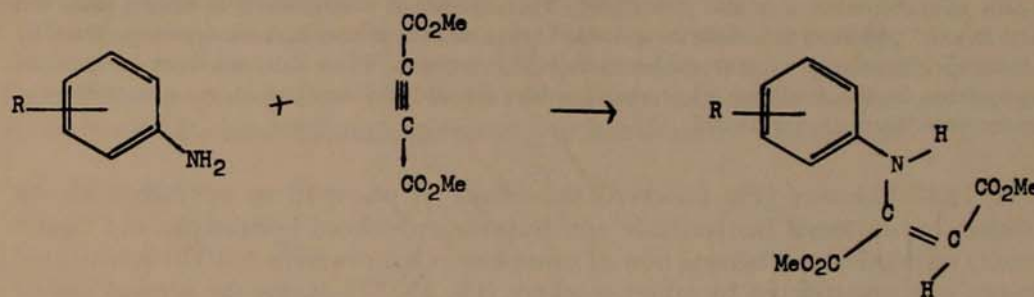
Thomas F. Lemke, Donna Borkowski, and Tulsı Sutaria

Department of Chemistry

Marshall University, Huntington, West Virginia 25701

Abstract

Primary aromatic amines and dimethyl acetylenedicarboxylate can be combined to form 1:1 Michael-type adducts of fumarate geometry. (1)



A series of meta and para substituted adducts have been synthesized. The chemical shift of the vinyl proton in these adducts can be correlated with Hammett sigma values.

The constancy of the ortho-effect was determined using the adducts from ortho-nitroanilines and ortho-carboxyanilines.

A change from chloroform to dimethyl sulfoxide as solvent for the ortho-carboxy series results in a change of correlation with sigma to sigma plus values.

Literature Cited

1. R. Huisgen, K. Herbig, A. Siegel, and H. Huber. 1966. *Chem. Ber.* 99:2526.

The Mechanism of the von Braun Amide Degradation

B. A. Phillips, J. Gal, and G. Fodor*

Department of Chemistry

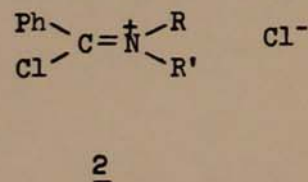
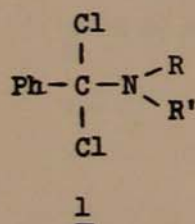
West Virginia University, Morgantown, West Virginia 26506

Abstract

This paper reviews the work that has recently been carried out in our laboratory without including preparative details. It was found that the reaction of N,N-dialkylbenzamides with carbonyl bromide or with phosphorus pentabromide gives, initially, the corresponding α -bromoiminium bromides. Excess carbonyl bromide or bromine in the medium converts these salts to tribromides, which can be reconverted to the monobromides using cyclohexene. The thermolysis of α -bromobenziminium bromides first gives an alkyl bromide and an imidoyl bromide. A new synthesis of imidoyl bromides from N-alkylamides and phosphorus pentabromide was also developed. Thermolysis of benzimidoyl bromides gives the "von Braun" products benzonitrile and alkyl bromide. These conclusions were supported by a mass spectral study of α -bromobenziminium bromides. These salts may have important applications in the synthesis of aromatic aldehydes and ketones and in the preparation of nitrogen-containing heterocycles.

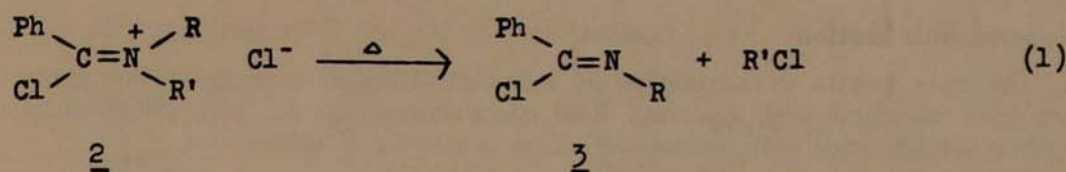
In 1847 Cahours (13) observed the effect of phosphorus pentachloride on amides: he obtained benzonitrile and butyronitrile from benzamide and butyramide, respectively. The reaction of phosphorus halides with N-alkyl substituted amides was investigated by other workers (18, 25, 31) during the second half of the last century. It was Julius von Braun, however, who placed the chemistry of the reaction on a firm basis with his admirable studies extending from 1904 over a period of 30 years (4, 20).

Von Braun showed (5) that N,N-dialkylsubstituted benzamides react with phosphorus pentachloride to give what he called "amidechloride" and represented as the covalent dihalide 1. More recent work (3) has shown, however, that these compounds exist in the ionic form 2.

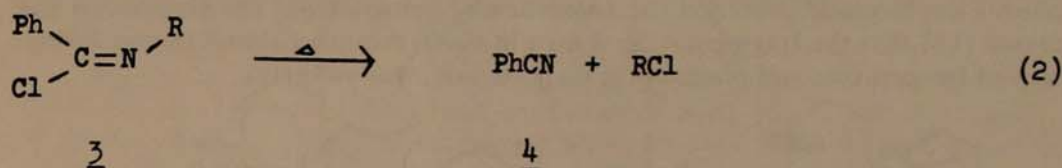


Von Braun was unable to isolate analytically pure samples of these iminium chlorides 2 but characterized them by hydrolysis to the parent amides and by conversion to their amidine derivatives (5). Thermal decomposition (6, 10) of these salts 2 gave an alkyl chloride and an imidoyl chloride 3 according to equation 1.

*Senior author to whom correspondence should be directed.



Further heating of the imidoyl chlorides 3 yields (7, 30) the "von Braun products", benzonitrile 4 and alkyl chloride (eq. 2).

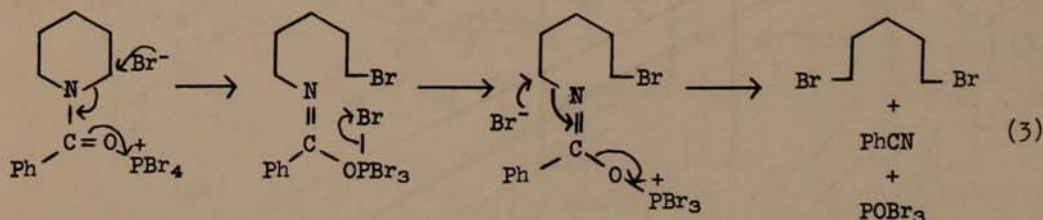


Von Braun also demonstrated (10) that thionyl chloride can be used in the synthesis of α -chloroiminium and imidoyl chlorides.

Using phosphorus pentabromide von Braun was able to prepare (9) several alkyl bromides from N-monosubstituted benzamides, and 1,5 dibromopentane from N-benzoylpiperidine (8). However he was unable to isolate any intermediate α -bromobenziminium bromides 5 or benzimidoyl bromides 6.



In fact, a search of the literature revealed that no bromoiminium bromide has been isolated from the reaction of an amide with phosphorus pentabromide. Similarly no N-alkyl or N-aryl imidoyl bromides seem to have been reported. Indeed, some authors believe (2,9) that imidoyl bromides may be too unstable to be isolated. A study of the mechanism of the von Braun reaction using phosphorus pentabromide was published in 1949 by Leonard and Nommensen (21). They did not observe or even postulate bromoiminium bromides or imidoyl bromides as intermediates and suggested an $\text{S}_{\text{N}}2$ type all concerted mechanism (eq. 3).



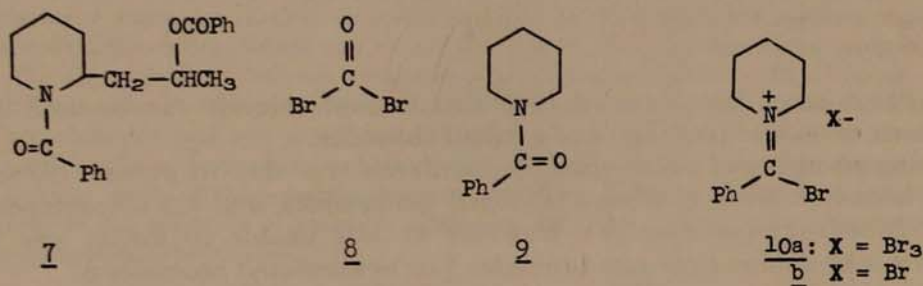
This mechanism is basically different from that proposed for the phosphorus pentachloride reaction (6, 7). Therefore a more detailed study of the mechanism of the von Braun reaction seemed warranted, especially in view of its value in the structure determination of alkaloids, e.g., quinine (26), sedridine (12), and conhydrine (14).

Experimental Section

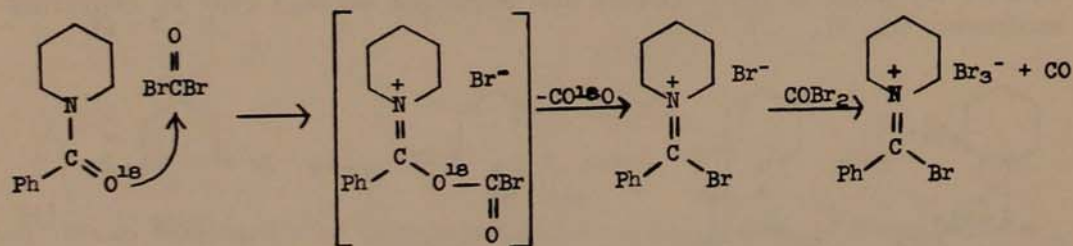
The mass spectra were recorded on a Nuclide 12-90-G instrument. Pmr spectra were obtained with a Varian T-60 spectrometer, on *ca.* 10% solutions in carbon tetrachloride with tetramethylsilane as internal reference.

Results and Discussion

The initial observation was made (12, 15) that in the reaction of N,O-dibenzoylsedridine **7** with phosphorus pentabromide the formation of phosphorus oxybromide preceded the formation of benzonitrile. The conclusion was drawn (15) that the fragmentation shown in eq. 3, requiring simultaneous formation of benzonitrile and phosphorus oxybromide, was unlikely.

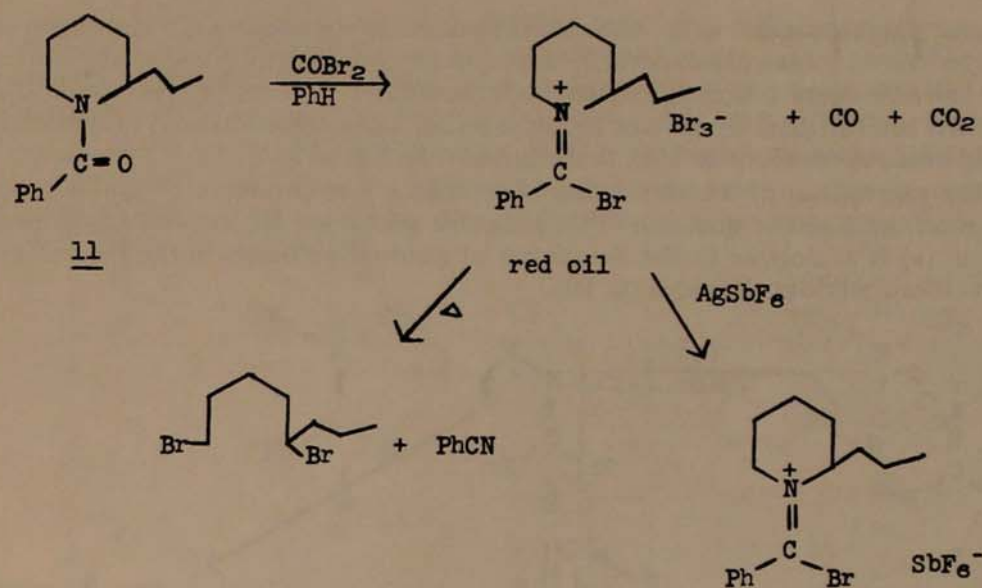


In order to avoid the rather harsh conditions created by phosphorus pentabromide, and thus to permit a more profound mechanistic study, carbonyl bromide **8** (1) was applied (17) to the von Braun reaction. When carbonyl bromide was used as solvent and reactant with N-benzoylpiperidine **9** a red solid was formed along with liberation of carbon monoxide and carbon dioxide. Spectral data and elemental analysis showed that the solid was N,N-pentamethylene- α -bromobenziminium tribromide **10a**. It was shown (16) that the tribromide was formed from the monobromide **10b** via reaction with carbonyl bromide. In fact, the reaction of ammonium bromides with carbonyl bromide to give the corresponding tribromides represents a new synthesis of these salts (16). The mechanism of the attack of carbonyl bromide on N,N-dialkylamides was elucidated using ^{18}O labeling (17). Scheme 1 summarizes these results.



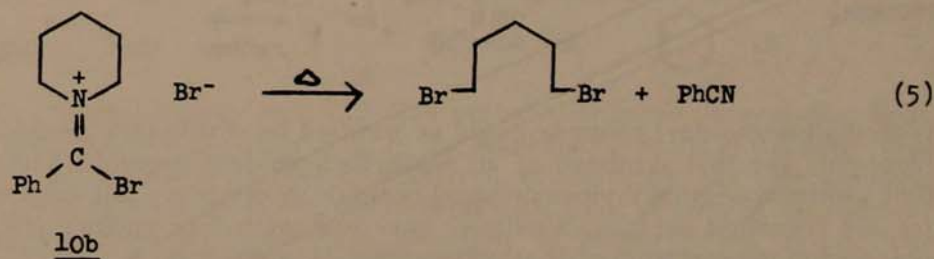
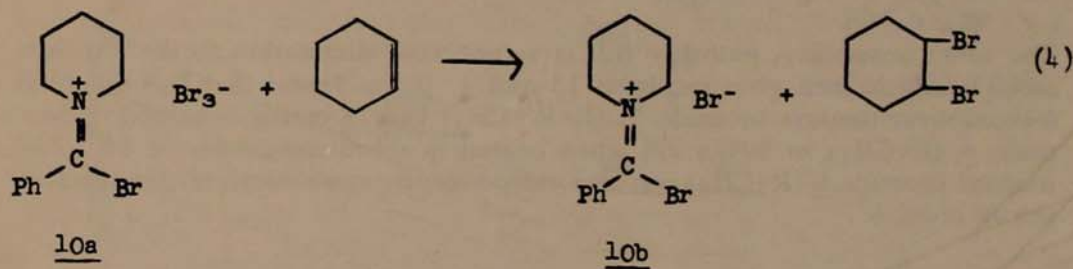
Scheme 1

The reaction of benzoylconiine **11** with carbonyl bromide in benzene takes a similar course (17). The intermediate tribromide salt (a red oil) was converted to the crystalline hexafluoroantimonate. Thermolysis of the tribromide gave a moderate yield of the von Braun products, *i.e.*, 1,5-dibromooctane and benzonitrile (Scheme 2), also obtainable from the reaction of benzoylconiine with phosphorus pentabromide (11).



Scheme 2

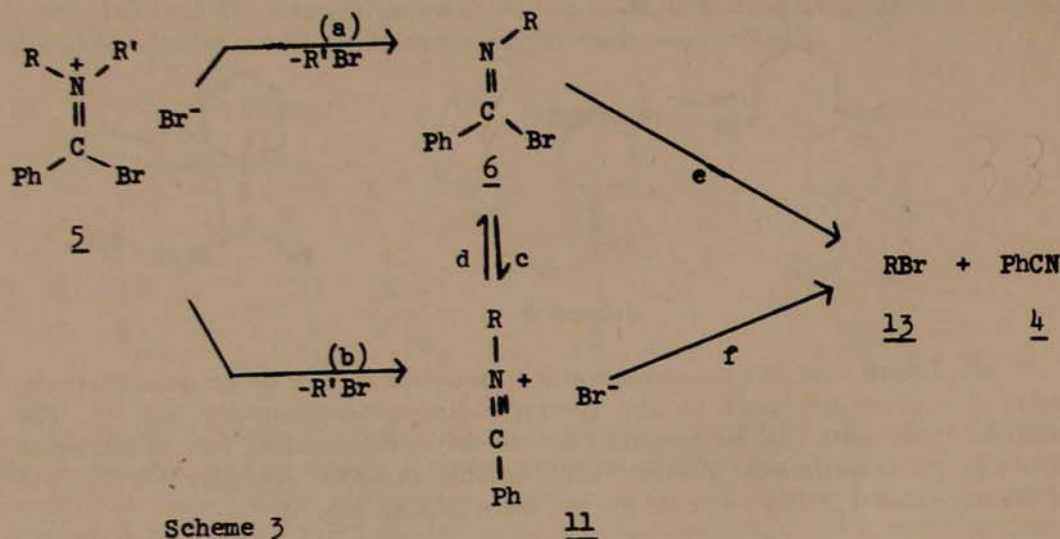
It was found that the bromoiminium tribromide salts may be quantitatively reduced with cyclohexene to the corresponding monobromides (eq. 4). The monobromide salts can be thermolyzed to the corresponding von Braun products e.g., pentamethylene α -bromo-benziminium bromide **10b** gave a 92% yield of the expected 1,5-dibromopentane and benzonitrile (eq. 5).



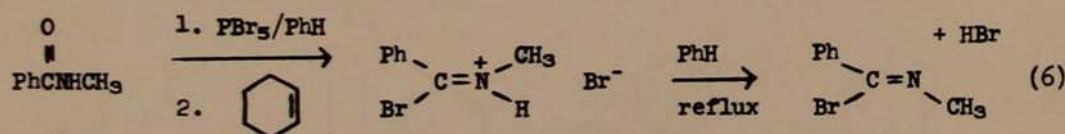
Since phosphorus pentabromide partially dissociates into phosphorus tribromide and bromine (19), tribromide salts may also form when this reagent is used. Indeed, previous failure (9, 21) to isolate any intermediates in the von Braun reaction using phosphorus pentabromide may have been caused by partial tribromide formation. In fact, it was found that the reaction of excess phos-

phorus pentabromide with N,N-dialkylamides in benzene or chloroform at 40°-50° for 2-3 hours, followed by addition of cyclohexene gives good yields of the corresponding α -bromoiminium monobromides 5. Thus it was shown that the first intermediate in the von Braun reaction using either carbonyl bromide or phosphorus pentabromide is an α -bromoiminium bromide, 5.

The conversion of α -bromoiminium bromides 5 to products 13 and 4 posed the next mechanistic question. Two plausible pathways are shown in Scheme 3. Route (a) is analogous to the formation of imidoyl chlorides in the thermolysis of α -chloroiminium chlorides (6, 10).



The other possibility, pathway (b), is a concerted elimination to the nitrilium salt 11, which then gives products 13 and 4. It was found that N,N-dimethyl α -bromobenziminium bromide 5, ($R=R'=\text{CH}_3$) gave N-methylbenzimidoyl bromide 6 ($R=\text{CH}_3$) in 50% yield when heated in dibromomethane at 96°. The imidoyl bromide 6 ($R=\text{CH}_3$) was also independently synthesized *via* the reaction shown in eq. 6.

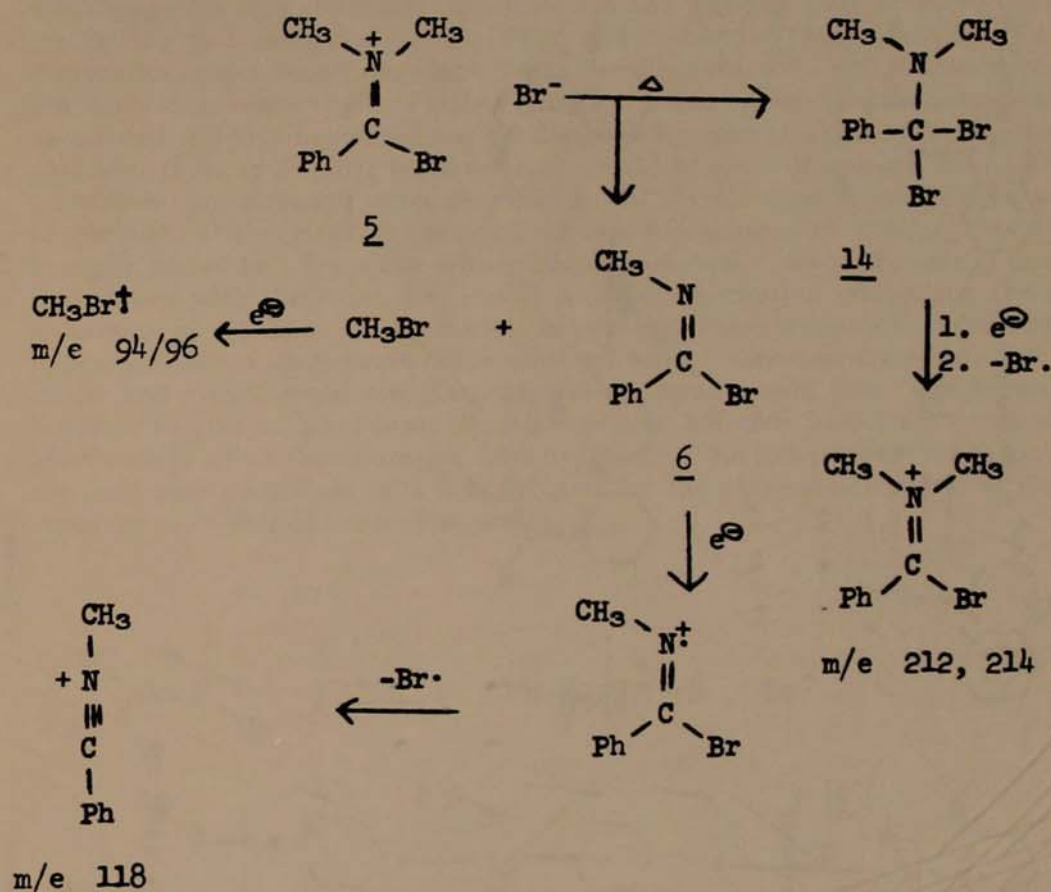


N-methylbenzimidoyl bromide could be purified by distillation in vacuum. This represents the first synthesis of an N-alkylbenzimidoyl bromide. The 60 MHz pmr spectrum of N-methylbenzimidoyl bromide showed only one singlet (δ 3.40) for the N-methyl protons. Similarly, only one methylene quartet (δ 3.66) was observed in the spectrum of N-ethylbenzimidoyl bromide (6, $R=\text{CH}_2\text{CH}_3$).

The thermal decomposition of N-methylbenzimidoyl bromide gave benzonitrile 4, and methyl bromide 13 ($R=\text{CH}_3$).

Thus the intermediacy of imidoyl bromides in the thermal decomposition of α -bromoiminium bromides was demonstrated. This was confirmed by a mass spectral study. When ammonium salts are heated in the inlet system of the mass spectrometer thermal reactions take place leading to neutral products which are

then volatilized and give rise to the observed spectrum. N,N-dimethyl α -bromobenziminium bromide, when heated at *ca.* 100-140° in the direct inlet system of the mass spectrometer, gave rise to a spectrum in which the major ions had *m/e* 214 (18%), 212 (18%), 118 (100%), 96 (49%), 94 (49%). The spectrum is rationalized on Scheme 4. Thermolysis gives N-methylbenzimidoyl bromide 6 (*R*=CH₃) which volatilizes, and upon electron impact loses a bromine atom to give the nitrilium ion of *m/e* 118. The other product of the thermal dealkylation is methyl bromide, *m/e* 94, 96.



Scheme 4

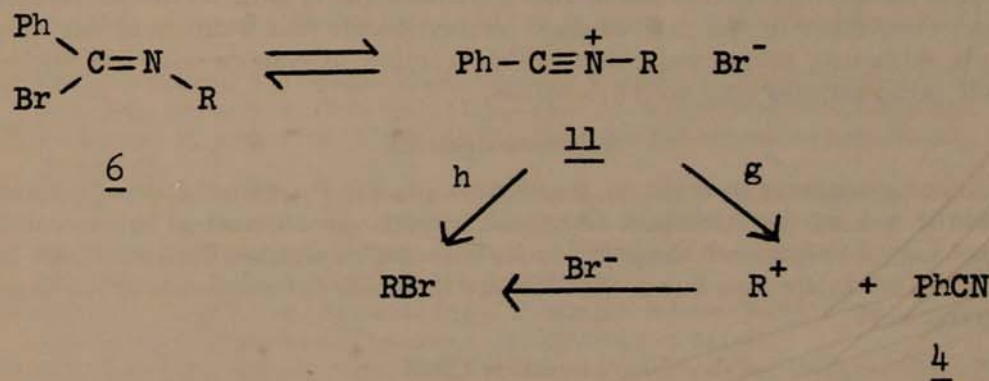
The bromoiminium ions of *m/e* 212, 214 probably arise *via* the *gem*-dibromide 14, which is the covalent form of 5. In the solid state 5 exists in the ionic form (3), but in the gas phase 14 may be preferred. Interestingly, the corresponding *gem*-difluorides, which are stable, distillable liquids, exist entirely in the covalent form (3). As expected, the mass spectrum of independently synthesized N-methylbenzimidoyl bromide showed no parent peak but a base peak at *m/e* 118, and its fragmentation ions.

Using N-benzoylpiperidine 9 and 1,5-dibromopentane 15 as starting materials, the reaction sequence and mass spectral study shown on Scheme 5 confirmed the conclusion that conversion of an N,N-dialkylbenzamide to bromoalkane(s) and benzonitrile proceeds *via* an α -bromobenziminium bromide, which in turn is



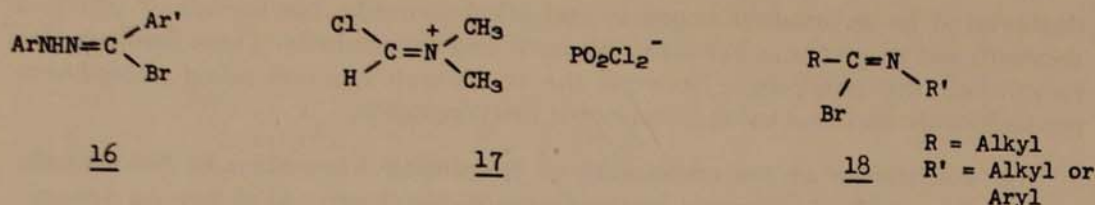
dealkylated to an imidoyl bromide and alkyl bromide, the former of which is thermolyzed to give another alkyl bromide and benzonitrile. These findings also established the parallelism between the von Braun reaction using phosphorus pentachloride and that using phosphorus pentabromide.

The mechanism of the conversion of benzimidoyl bromides to benzonitrile and alkyl bromide is currently in the focus of our efforts. As shown on Scheme 3, this step may, in principle, occur *via* a concerted elimination, pathway e, or, more probably, *via* dissociation into nitrilium and bromide ions, 11 (path c). Imidoyl bromides may dissociate into nitrilium and bromide ions as supported by the finding that imidoyl chlorides (29) 3 and hydrazidoyl bromides (28) 16 hydrolyze *via* initial dissociation into N-alkylnitrilium chlorides and N-aminonitrilium bromides, respectively. Furthermore, our observation that no geometrical isomers of imidoyl bromides can be detected by nmr at ambient temperature speaks in favor of a rather rapid interconversion of *syn-anti* isomers, perhaps *via* a nitrilium ion, although other mechanisms for the interconversion (23) cannot be excluded at this stage. A study of the rate of exchange of covalently bound bromide in imidoyl bromides with external radioactive ionic bromide is being undertaken with the hope that it will provide information concerning the relationship of nitrilium ion formation to *syn-anti* isomerization of imidoyl bromides. As shown on Scheme 6 the nitrilium ion 11 may dissociate into benzonitrile and a carbonium ion (path g), and the latter would then combine with bromide to give an alkyl bromide. Alternatively, bromide ion could attack the alkyl moiety of the nitrilium ion directly (path h). An independent synthesis of the appropriate nitrilium salts is in progress for the purpose of comparing their reactivity with that of imidoyl bromides.



Scheme 6

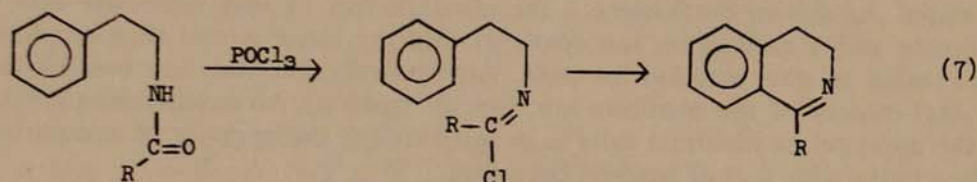
A further perspective of the present work involves three reactions where haloiminium halides or imidoyl halides are intermediates. One such reaction is the Vilsmeier-Haack (24) formylation of aromatic compounds using dimethylformamide and phosphorus oxychloride. It was recently shown (22) that the dimethylformamide-phosphorus oxychloride adduct has the chloroformimidinium dichlorophosphate structure, 17.



Whether the actual electrophilic intermediate is the chloroformiminium ion of 17 or a species derived from it, e.g. a nitrilium ion, is currently under investigation. Furthermore, the use of bromoiminium bromides or imidoyl bromides, which contain a better leaving group, may permit extension of the Vilsmeier-Haack reaction to the formylation of less reactive aromatics.

Similarly, the Houben-Hoesch ketone synthesis (27) using *in situ* formed imidoyl chlorides having an N-H group may be improved by using N-alkyl or N-aryl imidoyl bromides, 18.

The widely used Bischler-Napieralski isoquinoline synthesis (32) is another reaction where haloiminium halides or imidoyl halides may be intermediates. The reaction may be interpreted, as shown on eq. 7, to proceed *via* a nucleophilic attack by the ring carbon upon an imidoyl chloride.



Here again, replacing the chloride with bromide and, isolating the intermediate imidoyl halide may well result in considerable improvement in yields. Furthermore, conversion of the intermediate imidoyl halide into a nitrilium salt using Lewis acids may permit extension of this reaction to systems with less nucleophilic ortho carbons than used heretofore.

Acknowledgments

Acknowledgment is made to the donors of The Petroleum Research Fund, administered by the American Chemical Society, for support of this research. Thanks are due Research Corporation for a Frederick Gardner Cottrell Grant (to G. F.). Thanks are also due to Mr. Robert R. Smith for assistance in the mass-spectral work.

Literature Cited

1. Bartal, A. Von. 1906. Ueber das Kohlenoxybromid. *Ann.* 345:334-53.
2. Bonnett, R. 1970. Imidoyl halides. In *The Chemistry of the Carbon-Nitrogen Double Bond*, Ed. by S. Patai, p. 601. Wiley-Interscience Publishers.
3. ——. 1970. Imidoyl halides. In *The Chemistry of the Carbon-Nitrogen Double Bond*, Ed. by S. Patai, p. 615. Wiley-Interscience Publishers.
4. Braun, J. von. 1934. Amid- und Imidchloride, ihre Umformungen und synthetischen Verwendungen. *Angew. Chem.* 47:611-15.
5. ——. 1904. Darstellung trialkylierter Amidine. *Ber.* 37:2678-85.
6. ——. 1904. Ueber die Entalkylierung sekundärer Amine. *Ber.* 37:2812-19.
7. ——. 1904. Ueber eine neue Methode zur Aufspaltung cyclischer Amine. *Ber.* 37:2915-22.

8. ——. 1904. Ueber 1.5-Dibrom-pentan. *Ber.* 37:3210-13.
9. Braun, J. von, and C. Miller. 1906. Ueber Imidbromide und Ihre Spaltung. *Ber.* 39:2018-22.
10. Braun, J. von, and W. Pinkernelle. 1934. Thionylchlorid als bequemer Ersatz für Phosphorpentachlorid im Gebiet der Imidchloride. *Ber.* 67:1218-20.
11. Braun, J. von and E. Schmitz. 1906. Umwandlung des Coniins in Dichloroctan und Dibrom-octan. *Ber.* 39:4365-69.
12. Butruille, D., G. Fodor, C. Saunderson Huber, and F. Letourneau. 1971. Absolute configuration of the alkaloid (+) sedridine and of (–)allosedridine. *Tetrahedron.* 27:2055-67.
13. Cahours, A. 1847. Recherches sur l'action du perchlorure de phosphore sur les substances organiques. *Compt. Rend.* 25:724-26.
14. Fodor, G., E. Bauerschmidt, and J. Cymerman Craig. 1969. Absolute configuration of conhydrine. *Can. J. Chem.* 47:4393-97.
15. Fodor, G., and D. Butruille. 1968. Novel method of configurational correlation: (+)-sedridine and (+)-octan-2-ol. *Chem. Ind. (London)* 1437-38.
16. Fodor, G., and B. A. Phillips. 1971. Some applications of carbonyl bromide in organic chemistry. Abstracts of Papers, 162nd ACS National Meeting, Washington, D. C. ORGN No. 19.
17. Fodor, G., J. J. Ryan, and F. Letourneau. 1969. Isolation of iminium bromides as intermediates in the von Braun Reaction. *J. Amer. Chem. Soc.* 91:7768.
18. Gerhardt, C. 1858. Ueber die Einwirkung des Phosphorsuperchlorids auf einige Amide. *Ann.* 108:214-23.
19. Harris, G. S., and D. S. Payne. 1956. Non-aqueous solutions of phosphorus pentabromide. *J. Chem. Soc.* 4617-21.
20. Kurtz, P. 1966. Julius von Braun. *Chem. Ber.* 99:35-86.
21. Leonard, N. J., and E. W. Nommensen. 1949. Studies on the mechanism of the von Braun reaction. *J. Amer. Chem. Soc.* 71:2808-13.
22. Martin, G., and M. Martin. 1963. Recherches sur la reaction Vilsmeier-Haack. 1. Etude de la structure des complexes intermediaires par resonance magnetique nucleaire. *Bull. Soc. Chim. France.* 1637-46.
23. McCarty, C. G. 1970. Syn-anti Isomerizations and rearrangements. In *The Chemistry of the Carbon-Nitrogen Double Bond*, Ed. by S. Patai, p. 405. Wiley-Interscience Publishers.
24. Olah, G. A., and S. J. Kuhn. 1964. Vilsmeier reaction. In *Friedel-Crafts and Related Reactions*, Ed. by G. A. Olah, vol. 111, pp. 1211-24. Wiley-Interscience Publishers.
25. Pechmann, H. von. 1900. Ueber die Spaltung des Benzenylmethylimidchlorids. *Ber.* 33:611-12.
26. Prelog, V., and E. Zalan. 1944. Über China-Alkaloide. Über die Konfiguration der asymmetrischen Kohlenstoffatome 3, 4 und 8 der China-Alkaloide. *Helv. Chim. Acta.* 535-45.
27. Ruske, W. 1964. Houben-Hoesch and Related Syntheses. In *Friedel-Crafts and Related Reactions*, Ed. by G. A. Olah, vol. 111, pp. 383-497.
28. Scott, F. L., and J. B. Aylward. 1965. Hydrazidic halides, Part IV. The solvolysis of *p*-substituted benzhydrazidic bromides. *Tetrahedron Let.* 841-47.
29. Ugi, I., F. Beck, and U. Fetzer. 1962. Hydrolyse von Carbonsäure-Imidchloriden. *Chem. Ber.* 95:126-35.
30. Vaughan, W. R., and R. D. Carlson. 1962. The von Braun reaction. I. Scope and limitations. *J. Amer. Chem. Soc.* 84:769-74.
31. Wallach, O. 1882. Ueber die Einwirkung von Phosphorpentachlorid auf Saureamide. *Ann.* 214:193-327.
32. Whaley, W. M., and T. R. Govindachari. 1951. The preparation of 3,4-dihydroisoquinolines and related compounds by the Bischler-Napieralski reaction. In *Organic Reactions*, Ed. by R. Adams, vol. 6, pp. 74-150.

Condensation Reactions of Diethyl Oxomalonate

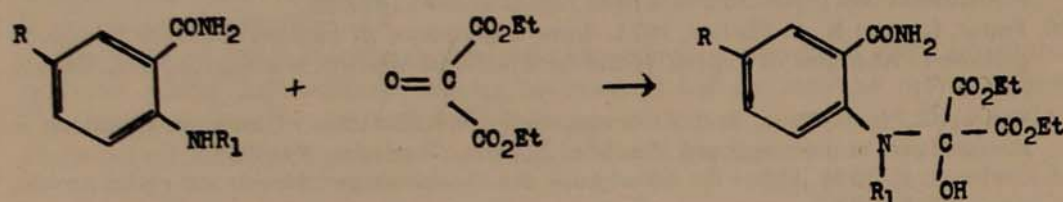
Thomas F. Lemke and Khizar Wasti

Department of Chemistry

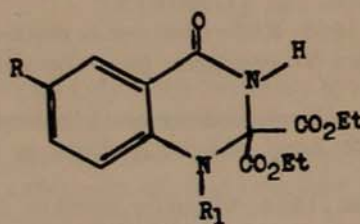
Marshall University, Huntington, West Virginia 25701

Abstract

The reaction of diethyl oxomalonate with anthranilamide and 5-chloro-, N-methyl-, 5-methyl-, and 5-bromoanthranilamide yields 1:1 crystalline adducts [70-90%] whose spectroscopic properties are consistent with an amino-alcohol structural assignment.



These adducts were found to be resistant to dehydration. Under vigorous reaction conditions, such as heating above 100° in polyphosphoric acid, they were converted to a heterocycle tentatively assigned as a quinazolinone.



The Synthesis of Cyclic N-Cyanoguanidines

Carolyn M. Baltzer and C. Gordon McCarty

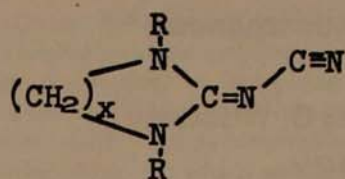
Department of Chemistry

West Virginia University, Morgantown, West Virginia 26506

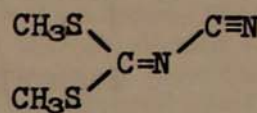
Abstract

Cyclic N-cyanoguanidines have not been previously reported in the chemical literature. We undertook the synthesis of such compounds because of the reported hypotensive activity of some acyclic N-cyanoguanidines (1) and because of their potential use as anti-malarials (2).

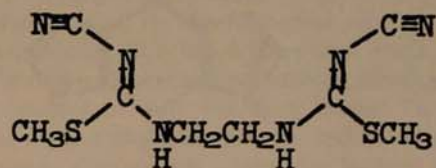
The compounds synthesized have the general formula I and are obtained from the reaction of dimethyl cyanoimidodithiocarbonate (II) with various primary and secondary



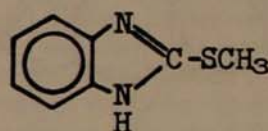
I $x = 2, 3$
 $R = H, CH_3$



II



III



IV

diamines. The reactions proceed quite readily at the reflux temperature of dry benzene. Five and six membered rings have been prepared using ethylenediamine, N,N'-dimethylethylenediamine, 1,3-propanediamine, and N,N'-dimethyl-1,3-propanediamine in yields of 41-80%. The products all show three distinct bands in the infrared spectrum: $2195-2175\text{ cm}^{-1}$ ($C\equiv N$), $1630-1550\text{ cm}^{-1}$ ($C=N$), and 1290 cm^{-1} ($C-N$). Their respective nmr spectra are consistent with the assumed structures. Correct microanalyses were obtained for each product.

In the case of the reactions using ethylenediamine, the total yield ($\sim 81\%$) was almost equally divided between the expected cyclic guanidine and a high melting material which proved to be III. The reaction gave III under a variety of conditions. Such a side product was not obtained in any of the reactions with the other diamines.

The cyclic guanidines were all pure, white crystalline solids except the product from the reaction involving N,N'-dimethyl-1,3-propanediamine which was a yellow oil. The products from the secondary diamines were much more soluble in common organic solvents than those obtained from the reactions of the primary diamines.

The reaction of II with o-phenylenediamine did not yield the expected cyclic N-cyano-guanidine. The product actually obtained in this reaction was found to be a benzimidazole (IV).

Literature Cited

1. Gadekar, S. M., S. Nibi, and E. Cohen, 1968. Hypotensive Activity of Some Cyano-guanidines. *J. Med. Chem.* 11:811-14.
2. May, E. L. 1947. Attempts to Find New Antimalarials. *J. Org. Chem.* 12:437-42.

Some Thiophene Analogs of Anthraquinone

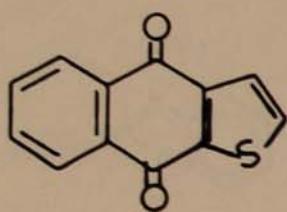
Denis W. H. MacDowell and James C. Wisowaty

Department of Chemistry

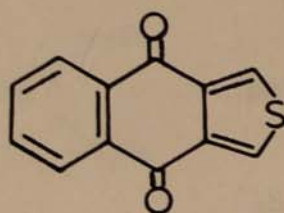
West Virginia University, Morgantown, West Virginia 26506

Abstract

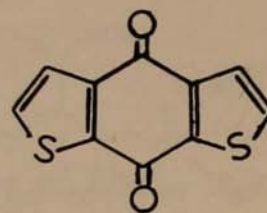
Six possible isomers resulting from the replacement of one or both benzene rings in 9,10-anthraquinone with thiophene rings have been synthesized.



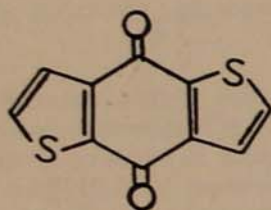
1



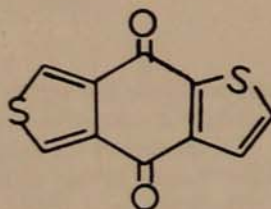
2



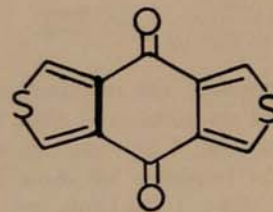
3



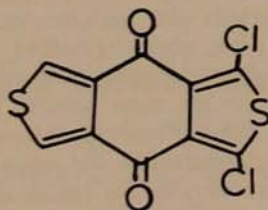
4



5



6



7

The synthesis of 4,9-dihydronaphtho[2,3-b]thiophene-4,9-dione (**1**) was accomplished by cyclization of the known ortho(2-thenoyl)benzoic acid by means of aluminum chloride. The synthesis of 4,9-dihydronaphtho[2,3-c]thiophene-4,9-dione (**2**) was achieved by the Friedel-Crafts diacylation of benzene using thiophene-3,4-dicarbonyl chloride. 4,8-Dihydrobenzo[1,2-b:5,4-b']dithiophene-4,8-dione (**3**) was obtained by oxidation of the known 8-acetoxybenzo[1,2-b:5,4-b']dithiophene, (MacDowell, D. W. H., and J. C. Wisowaty, 1971, Keto-Enol Tautomerism in the Thiophene Analogs of Anthrone. II. Benzodithiophenes. *J.*

Org. Chem. 36:4004). 4,8-Dihydrobenzo[1,2-b:4,5-b¹]dithiophene-4,8-dione (4) resulted from similar oxidation of the analogous 4-acetoxybenzo[1,2-b:4,5-b¹]dithiophene. Friedel-Crafts diacylation of thiophene with thiophene-3,4-dicarbonyl chloride afforded 4,8-dihydrobenzo[1,2-b:4,5-c¹]dithiophene-4,8-dione (5). Similar reaction of the above diacid chloride with 2,5-dichlorothiophene yielded 1,3-dichloro-4,8-dihydrobenzo[1,2-c:4,5-c¹]dithiophene (7) which was dechlorinated by copper in refluxing propionic acid to give 4,8-dihydrobenzo[1,2-c:4,5-c¹]dithiophene-4,8-dione (6).

The compounds 1, 2, 3, 4, 5 and 7 were subjected to reduction by means of an equimolar mixture of aluminum chloride-lithium aluminum hydride. Compounds 3 and 4 show only reduction to the hydroquinone stage (90%). Compounds 2 and 7 provide good yields of the respective dihydro compounds (70%). Compounds 1 and 5 provide only moderate yields of the dihydro compounds 25% and 32% respectively. A 40% yield of naphtho[2,3-c]thiophene was also obtained from the reduction of 1. Recent studies (MacDowell, D. W. H. and J. C. Wisowaty, 1971. Keto-Enol Tautomerism in the Thiophene Analogs of Anthrone, I. Derivatives of Naphtho[2,3-b]thiophene and Naphtho[2,3-c]thiophene. *J. Org. Chem.* 36:3999; MacDowell, D. W. H. and J. C. Wisowaty, 1971. Keto-Enol Tautomerism in the Thiophene Analogs of Anthrone II. Benzodithiophenes. *J. Org. Chem.* 36:4004) have shown that in the keto-enol tautomerism of anthrone analogs of 1-6, those compounds containing di b-fused thiophene rings, the predominant form present was the enolic modifications, whereas derivatives containing mono and di c-fused thiophene rings showed the presence of only the keto forms. The mechanism presented to explain the course of the hydride-aluminum chloride reduction of the diones rests largely on the fact that where the stable compounds containing b-fused thiophene rings could result, these were produced in preference to secondary reduction to the dihydro aromatic compound as was observed in the case of the mono and di c-fused cases.

Cavity-Molecule Isolation Techniques of the Structure of Radicals Produced by Gamma-Radiolysis

Ron E. Linder and A. Campbell Ling

Department of Chemistry

West Virginia University, Morgantown, West Virginia 26506

Abstract

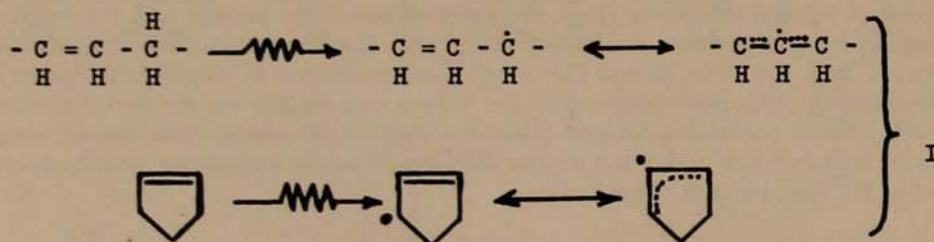
Matrix isolation techniques involving glassy, crystalline, and polycrystalline, matrices are well documented. The major disadvantage of such techniques is that anisotropic interactions between the radical under investigation and the matrix leads to wide lines and poorly resolved e.s.r. spectra, thus precluding the unambiguous assignment of a structure to a radical from its e.s.r. spectrum in all but the simplest radicals. We report here a new technique that offers all the advantages of both solid-state isolation methods (in particular, long radical lifetimes) and liquid phase studies (good resolution and narrow line e.s.r. spectra), together with the practical advantage of room temperature operation.

Adamantane offers a molecule that contains a large and well-defined cavity in its center. A radical created inside this cavity will be isolated in a unique manner compared to standard isolation techniques, and recombination reactions and other radical decay modes will be minimized. In addition, the radical will be able to tumble isotropically thus yielding isotropic liquid-phase e.s.r. spectra in the solid state. Such spectra have been detected and

utilized by several investigators (1-3) to determine radical structures in a variety of different systems. We report the use of cavity-molecule isolation techniques to determine the structure of radicals derived from aliphatic alkanes and aliphatic alkene derivatives.

In a typical experiment, to determine the structure of the radical derived from cyclopentane, adamantane was recrystallized from cyclopentane, the adamantane filtered off, dried on a warm hot plate, and the dry powder irradiated in an open Pyrex tube at room temperature by a cobalt-60 source. The irradiated powdered adamantane was transferred to a quartz e.s.r. tube and monitored at room temperature *via* a 9.5 GHz instrument. Analysis of the adamantane (g.l.c.) after recrystallization from the requisite solvent (which then becomes the solute molecule held in the adamantane) disclosed that the mole ratio adamantane/solute was between 500:1 and 1000:1.

General results indicated that normal alkanes suffered random C-H bond cleavage, but that secondary alkanes always underwent tertiary hydrogen loss. Tertiary hydrocarbons and polysubstituted alkanes led to ambiguous results, and these are being investigated further in this laboratory. Data from normal alkenes, and singly branched alkenes, indicated that the radical produced by radiolysis had an allylic structure (Scheme I). Ambiguous results were noted for alkynes, and molecules containing both a tertiary hydrogen and a double-bond.



Radical structures studied include the following: 2-methylpentane, 3-methylpentane, isopentane, cyclopentane, methylcyclopentane, cyclopentene, cyclohexane, cyclohexene, methylcyclohexane, iso-butene, butene-1, butene-2, 2-methylbutene-1, 2-methylbutene-2, 3-methylbutene-1, 2-pentene-2, 4-methylpentene-2, 2-methylpentene-1, 3,3-dimethylbutene-1, hexene-1, hexene-2, heptene-1, heptene-2, octene-1, nonene-1, cyclopentadiene, methylacetylene, and dimethylacetylene.

Literature Cited

1. Wood, D. E., R. V. Lloyd, and W. A. Lathan. 1971. *J. Amer. Chem. Soc.* 93:4157-59.
2. Gee, D. R., and J. K. S. Wan. 1971. *Can. J. Chem.* 49:20-26.
3. Kanick, S. W., R. E. Linder, and A. Campbell Ling. 1971. *J. Chem. Soc. (A)*:2971-73.

The Consequences and Significance of Protonating Ferrocene at the Metal

T. E. Bitterwolf and A. Campbell Ling

Department of Chemistry

West Virginia University, Morgantown, West Virginia 26506

Abstract

Electrophilic substitution in metallocenes has commanded considerable attention from a variety of different research groups, and much controversy has raged over the role of the metal atom in the intermediate formed en-route to the final product. Two basic mechanisms have been proposed: one involving a sigma-bonded intermediate formed *via* a pi-cloud interaction of the incoming electrophile with the cyclopentadienyl rings, the other a sigma-bonded intermediate formed *via* a complex involving metal-electrophile bonding. In view of the fact that ferrocene was known to protonate at the metal in strongly acidic media, (1), we felt that a re-investigation and extension of this aspect of ferrocene chemistry might shed some light on the mechanistic controversy described.

Ferrocene, and alkyl substituted ferrocenes, have been examined by n.m.r. spectrometry in $\text{BF}_3 \cdot \text{H}_2\text{O}$ solutions. Confirmation of earlier results were obtained; a broad singlet at *circa* 12 τ (pivalic acid or tetramethylammonium bromide used as internal standards) indicated a metal-bonded proton, and a sharp doublet at 5.06 τ indicated the ring protons, split by the metal-proton. On examining the methyl substituted ferrocenes, the 1-methyl ferrocene displayed two resonances at 5.15 τ and 5.22 τ , that at 5.22 τ being a broad singlet, while that at 5.15 τ was a sharply resolved doublet similar to that obtained from ferrocene itself. The 1,1'-dimethylferrocene exhibited a symmetrical doublet, centered at 5.23 τ , whose components were both broad lines similar to the high field singlet noted for the mono-methyl compound. We interpreted this to mean that protonation at the metal had caused the two rings in ferrocene to tilt away from their parallel conformation, so preventing free rotation of the substituted ring. No longer are all of the protons equivalent, and although distinct resonances for the alpha and beta protons cannot be distinguished, they do contribute to line broadening. That the line broadening is *not* due to alkyl group substituent effects can be seen clearly by comparison of protonated and parent alkyl-substituted ferrocene n.m.r. spectra, and by noting the very small effects caused by substituent alkyl groups (2). The stereochemical hindrance to rotation caused by protonation and consequent ring tilting was studied for 1-methyl, 1,1'-dimethyl-, 1-methyl-1'-ethyl-, 1,1'-diethyl-, 1-ethyl-, and 1-methyl-2,5-dideutero-ferrocene. This data has provided the first experimental demonstration of a hypothesis advanced on purely theoretical grounds by Ballhausen and Dahl (3), that protonation of ferrocene does lead to ring tilt. Further, protonation at the metal and the formation of the ferrocenonium ion, together with further studies of the chemistry of the ferrocenonium cation (4), have provided considerable support for the mechanistic approach of an electrophile *via* the metal and *not via* pi-cloud interaction, together with an overall rationalization of several previously unrelated and unexplained phenomena involving oxidation and ferricinium cation formation.

Literature Cited

1. Curphey, T. J., J. O. Santer, M. Rosenblum, and J. H. Richards. 1960. *J. Amer. Chem. Soc.* 82:5249-50.
2. Reinhard, K. L., D. E. Bublitz, and D. Gustafson. 1963. *J. Amer. Chem. Soc.* 85:970-73.
3. Dahl, J. P., and C. J. Ballhausen. 1961. *Acta Chem. Scand.* 15:1333-36.
4. Bitterwolf, T. E., and A. Campbell Ling. 1972. *J. Organometal. Chem.* 40:197-201.

Use of the Neutral Equivalent as an Aid in the Preparation and Characterization of Metal Ion Complexes of the Aminoalcohols

James L. Hall

Department of Chemistry

West Virginia University, Morgantown, West Virginia 26506

Abstract

Copper(II) nitrate and monoethanolamine react to form a crystalline complex compound for which the formula $\text{Cu}(\text{AOH})(\text{NO}_3)_2$ has been assigned upon the basis of copper and nitrogen analyses (2). Within experimental error, the copper and nitrogen analyses fit equally well the formula $\text{Cu}(\text{AO})(\text{AOH})\text{NO}_3$. In these formulas AOH represents monoethanolamine, $\text{H}_2\text{NC}_2\text{H}_4\text{OH}$, and AO^- represents the ion formed by loss of the hydroxyl proton from monoethanolamine. More complete elemental analyses and the determination of the equivalent weight of the compound by titration with acid show that the latter formula is correct. Likewise, a determination of the neutral equivalent of a complex formed from Copper(II) nitrate and diethanolamine $[\text{DOH}, \text{HN}(\text{C}_2\text{H}_4\text{OH})_2]$ shows that the formula probably is $\text{Cu}(\text{DO})(\text{DOH})\text{NO}_3$ and not $\text{Cu}(\text{DOH})(\text{C}_2\text{H}_5\text{OH})(\text{NO}_3)_2$ as reported (2).

In a further study it was shown that the form of the titration curve for addition of acid to a solution of a copper(II) acetate-monoethanolamine complex shows end points for addition of protons to each of three kinds of basic sites present: the alkoxide ion, the amine nitrogen, and the acetate ion.

The use of the neutral equivalent shown by these examples is generally applicable to complexes of the aminoalcohols.

A minimum formula weight for a crystalline metal complex compound may be found by an accurate elemental analysis for the metal. Frequently, for amine complexes, elemental analyses for the metal and for nitrogen give enough information to establish the formula. If nitrogen other than amine nitrogen is present, however, additional information may be required. In this report we show examples of compounds for which incorrect formulas may have been proposed on the basis of metal and nitrogen analyses but for which correct formulas may be inferred from these analyses plus a determination of the neutral equivalent. Equivalent weights from titration with acid may also be used as a quick, inexpensive guide to the purity of such complexes through several stages of preparation and recrystallization. Further, the form of the titration curve may give useful information about the nature of the bonding in the complex. One such example will be described.

Experimental Section

Analyses

Copper analyses were made by a conductometric titration of a solution of the complex with a solution of the disodium salt of ethylenediaminetetraacetic acid (1). Nitrogen analyses were made by a semi-micro Kjeldahl method. Additional nitrogen analyses and carbon and hydrogen analyses were made by the Galbraith

Laboratories. Neutral equivalents were determined by titration with approximately 0.1 N hydrochloric acid.

Preparation of Compounds

I. (2-Aminoethoxo)(2-aminoethanol)copper(II) nitrate, $\text{Cu}(\text{H}_2\text{NC}_2\text{H}_4\text{O})(\text{H}_2\text{NC}_2\text{H}_4\text{OH})\text{NO}_3$. Copper(II) nitrate trihydrate (0.05 mole) was dissolved in 30 ml of water. Monoethanolamine (0.25 mole) was added. After 4 hours evaporation on a steam bath, crystals formed from the very dark blue solution. They were separated and washed with methanol. The fluffy, deep blue crystals dissolve in water to form a deep blue solution which turns cloudy within a few minutes. *Anal.* Calcd. for $\text{CuC}_4\text{H}_{13}\text{O}_3\text{N}_3$: Cu, 25.7; N, 17.0; C, 19.5; H, 5.3; Neutral equiv., 82.2. Found: Cu, 25.4; N, 16.8; C, 19.7; H, 5.3; Neutral equiv., 82.3.

II. (2-Iminoethanol-2'-iminoethoxo)(2,2'-iminodiethanol)copper(II) nitrate, $\text{Cu}(\text{HOC}_2\text{H}_4\text{NHC}_2\text{H}_4\text{O})[(\text{HOC}_2\text{H}_4)_2\text{NH}]\text{NO}_3$. Copper(II) nitrate trihydrate (0.037 mole) was dissolved in the minimum amount of methanol (about 40 ml). Diethanolamine (0.165 mole) was added. The deep blue solution was evaporated on a steam bath until there was no further decrease in volume. The mixture was cooled and crystals were separated by repeated alternate working with methanol and acetone. Light blue crystals were obtained which form a deep blue solution in water. *Anal.* Calcd. for $\text{CuC}_8\text{H}_{21}\text{O}_7\text{N}_3$: Cu, 19.0; N, 12.3; Neutral equiv., 111.6. Found: Cu, 18.7; Neutral equiv., 111.0.

III. (2-Aminoethoxo)(2-aminoethanol)copper(II) acetate hemi-hydrate, $\text{Cu}(\text{H}_2\text{NC}_2\text{H}_4\text{O})(\text{H}_2\text{NC}_2\text{H}_4\text{OH})_2(\text{CH}_3\text{COO})(\frac{1}{2}\text{H}_2\text{O})$. Copper(II) acetate monohydrate (0.05 mole) was suspended in 50 ml of *iso*-propyl alcohol. Monoethanolamine (0.25 mole) was added. The mixture was filtered and a little insoluble residue was discarded. Bright blue crystals formed after about 3 hours. The crystals were separated by filtration in the absence of moisture and were washed with *iso*-propyl alcohol. The crystals form a bright blue solution in water. The compound is exceedingly deliquescent and decomposes rapidly in the presence of moist air. *Anal.* Calcd. for $\text{CuC}_8\text{H}_{24}\text{O}_{4.5}\text{N}_3$: Cu, 20.3; N, 13.4; Neutral equiv., 156.8 and 62.8. Found: Cu, 20.1; N, 13.6; Neutral equiv., 158.1 and 62.6.

Discussion

Hieber and Levy (2) reported the preparation of a compound from copper(II) nitrate and monoethanolamine for which they gave the formula $\text{Cu}(\text{H}_2\text{NC}_2\text{H}_4\text{OH})_2(\text{NO}_3)_2$. From the elemental analysis given, however, the formula is clearly intended to be $\text{Cu}(\text{H}_2\text{NC}_2\text{H}_4\text{OH})(\text{NO}_3)_2$. *Anal.* Calcd. for $\text{CuC}_2\text{H}_7\text{O}_7\text{N}_3$: Cu, 25.57; N, 16.90. Found: Cu 25.54; N, 16.84. Upon attempting to duplicate the preparation of Hieber and Levy we obtained a compound of similar physical description. The neutral equivalent determined for our compound was, however, one-third of the formula weight rather than equal to the formula weight as would be expected for the compound of Hieber and Levy. Subsequently we worked out the improved preparation described as compound I, above. We note that the copper and nitrogen analyses, and formula weights of the two compounds are identical within experimental error. This coincidence arises from the near identity of the formula weights of the nitrate ion, 62, and of the alkoxide ion, 60. We believe that the compounds obtained by Hieber and Levy and by us are identical and that our proposed formula is fully justified.

Hieber and Levy (2) reported, also, a compound prepared from copper(II)

nitrate and diethanolamine which was crystallized from ethanol, and for which the formula $\text{Cu}[\text{HN}(\text{C}_2\text{H}_4\text{OH})_2](\text{C}_2\text{H}_5\text{OH})(\text{NO}_3)_2$ was proposed. *Anal. Calcd.* for $\text{CuC}_6\text{H}_{16}\text{O}_9\text{N}_3$: Cu, 18.77; N, 12.41. Found: Cu, 18.81; N, 12.63. We prepared a compound of similar physical description, both with and without using ethanol as a crystallizing medium, and report our preparation of this compound as II, above. Note the near coincidence of the formula weights of the diethanolamine alkoxide ion, 104, and of the ethanol plus the nitrate ion, 108. Again, the neutral equivalent clearly shows the correctness of our proposed formula.

The compound III, above, is described because of the very interesting titration curve it gives upon addition of acid. The compound is so deliquescent and has such a short shelf life that we were unable to obtain commercial C, H, and N analyses. Our own copper and nitrogen analyses and neutral equivalents clearly establish the proposed formula. We are uncertain whether the one-half molecule of water is a part of the complex or simply represents our inability to prepare a moisture-free sample.

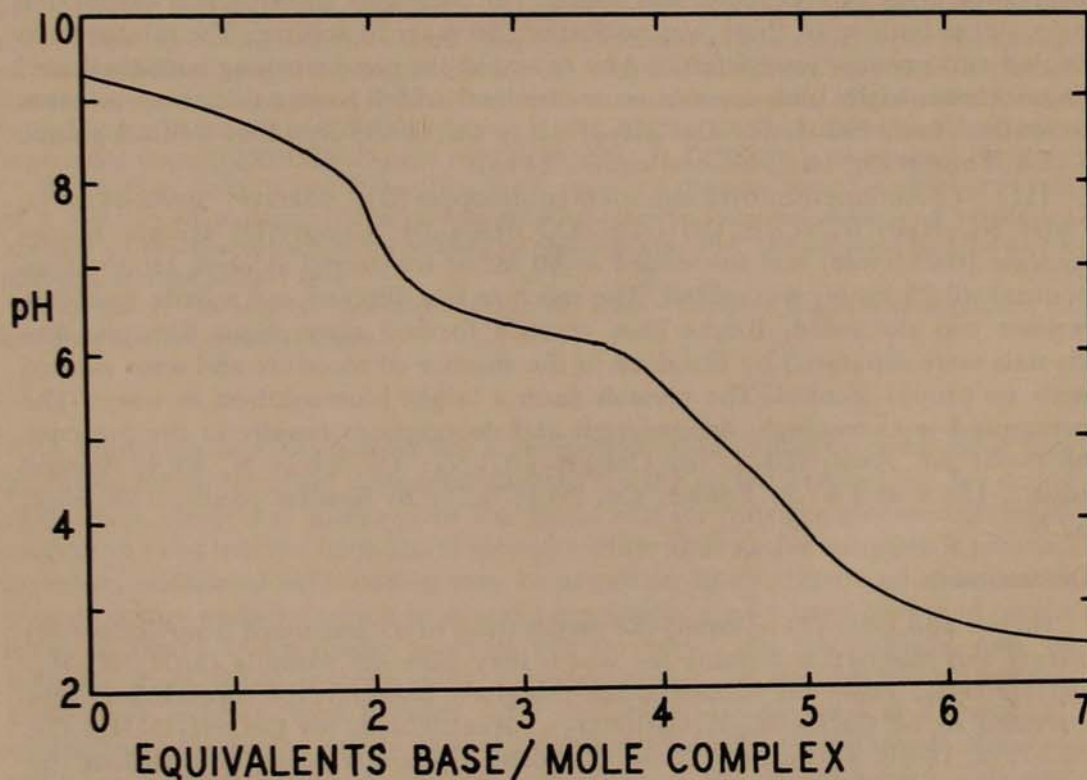
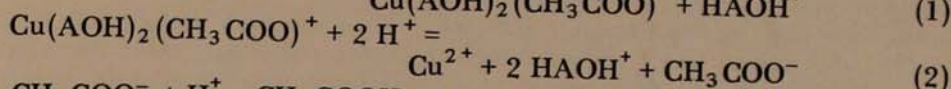
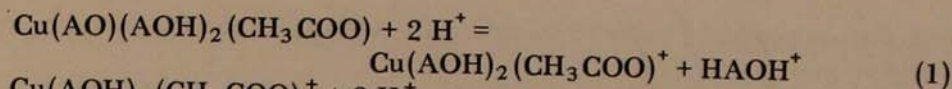


FIGURE 1. Titration of the copper(II) acetate-monoethanolamine complex with base.

The titration curve for addition of 0.1 *N* hydrochloric acid to a solution of the complex is shown as Figure 1. One very good and two less well-resolved end points are observed at a ratio of 2:4:5. The neutral equivalents are calculated for the first and last end points. We believe that the three end points represent completion of the steps shown in the following equations where AOH represents the monoethanolamine molecule, AO^- represents the ion formed by loss of the hydroxyl proton, and HAOH^+ represents the ammonium-type ion formed by addition of a proton to the amine nitrogen atom.



The use of the neutral equivalent shown by these examples is generally applicable to complexes of the aminoalcohols with labile metallic ions.

Acknowledgments

A number of graduate and undergraduate students have contributed to the thought and experimental work involved in solving these problems. These include John Fisher, Robert Simmons, Donald Brannon, Henry Berger, Donald Price, Jerry Sue Wilson, and Patricia B. King. Support was received under a contract from the Office of Ordnance Research, U. S. Army, and from the National Science Foundation through the Undergraduate Research Participation Program.

Literature Cited

1. Hall, J. L., J. A. Gibson, Jr., P. R. Wilkinson, and H. O. Phillips. 1954. Conductometric standardization of solutions of common divalent metallic ions. *Anal. Chem.* 26:1484-6.
2. Hieber, W., and E. Levy. 1934. Das komplexchemische Verhalten der Äthylolamine. *Z. anorg. allgem. Chem.* 219:225-37.

Mass Spectra and Bonding In Group VI Metal Pentacarbonyl Compounds

S. Thomas Bond

Department of Chemistry

Salem College, Salem, West Virginia 26426

and

Norman V. Duffy

Chemistry Department

Kent State University, Kent, Ohio 44240

Abstract

Nineteen organometallic carbonyl compounds of the type $\text{M}(\text{CO})_5\text{L}$ (where $\text{M} = \text{Cr}, \text{Mo}$ or W , and $\text{L} =$ trivalent compounds of $\text{N}, \text{P}, \text{As}$ and Sb , or pyridine) have been prepared, and the mass spectra of these compounds and the ligands taken. Cotton-Kraihanzel force constants and Graham σ and π parameters,² a measure of the sigma and pi donor-acceptor properties of the ligand, have been taken from the literature, or calculated from the carbonyl stretching bands in the infrared spectra for nine molybdenum compounds. σ and π

bonding in the compounds is discussed in terms of the effect on the CO stretching frequencies and the mass spectra.

With one exception, the fragmentation patterns of the compounds showed only ions in which the ligand remained intact while attached to the central metal atom. The relative abundance of ligand fragment ions, compared to the ligand molecular ion, is nearly the same in the mass spectra of the organometallic compounds and the mass spectra of the respective ligands. Metal-carbonyl ions $M(CO)_x^+$ (where $x = 1-5$) are an order of magnitude or more less abundant than metal-carbonyl ligand ions $M(CO)_x^+$ (where $x = 1-5$), and the metal-ligand ion ML^+ is the most abundant metal-containing ion in the spectrum, in most cases. Fragmentation patterns of the metal-ligand ions ML^+ are quite different from those of the ligand molecular ion L^+ .

Mass spectra of the chromium, molybdenum and tungsten compounds having the same ligand show differences in the relative abundances of ions which may be related to the probable strength of the M-CO bonds in the compounds.³ Compounds having an M-N bond showed thermal rearrangement in the source of the mass spectrometer, even at relatively low temperatures. Mass spectral and infrared properties of compounds having the ligands triparafluorophenylphosphine and pentafluorophenyldiphenylphosphine were similar to compounds having the ligand triphenylphosphine, in spite of the high electronegativity of fluorine atoms.^{4,5}

No strong correlation was found between any characteristic of the mass spectra and either the Graham σ or π parameters of the compounds. However, when the relative abundance of the molecular ion $M(CO)_5L^+$ is divided by the sum of the relative abundances of the $M(CO)_xL^+$ ions (where $x = 0-4$), the quantity decreases with increasing Graham π parameter.

Attempts to take the appearance potentials of these compounds from an all-glass heated inlet system were not successful, due to decomposition of the compounds before reaching the mass spectrometer source.

Literature Cited

1. Cotton, F. A., and C. S. Kraihanzel. 1962. *J. Am. Chem. Soc.* 84:4432.
2. Graham, W. A. G. 1968. *Inorg. Chem.* 7:315.
3. Chambers, D. B., F. Glockling, and R. J. C. Light. 1969. *Chem. Rev.* 69:317.
4. Parshall, G. W. 1966. *J. Am. Chem. Soc.* 88:704.
5. Stewart, R. P., and P. M. Treichel. 1970. *J. Am. Chem. Soc.* 92:2710.

A Study of Some Copper Complexes of N-methylamides

S. Gurunathan and M. R. Chakrabarty

Department of Chemistry

Marshall University, Huntington, West Virginia 25701

Abstract

N-methylamides contain two donor atoms, such as the nitrogen atom and the aldehydic oxygen atom. The ligands N,N dimethylformamide (DMF), N-methyl acetamide (NMA), and

N,N dimethylacetamide (DMA) have $\begin{array}{c} \diagup \quad \diagdown \\ \text{N}-\text{C} \\ \diagdown \quad \diagup \\ \parallel \\ \text{O} \end{array}$ linkage which makes the N-C bond partly a

double bond, as evidenced by nuclear magnetic resonance (nmr) spectra. It is of interest to

Table 1. Elemental Analysis of Copper Complexes of N-Methylamides.

	%C	%H	%N	%Cu
$\text{Cu}(\text{DMF})_2(\text{NO}_3)_2$				
Calculated	21.58	4.19	16.78	19.04
Found	21.44	3.95	17.07	19.04
$\text{Cu}(\text{DMA})_2(\text{NO}_3)_2$				
Calculated	21.58	4.19	16.78	19.04
Found	21.44	3.95	17.07	19.04
$\text{Cu}(\text{DMA})_2(\text{NO}_3)_2$				
Calculated	26.55	4.97	15.45	17.57
Found	26.14	5.55	15.55	17.17
$\text{Cu}(\text{NMA})_3(\text{NO}_3)_2$				
Calculated	26.55	5.16	17.21	15.63
Found	26.24	5.80	17.13	14.66

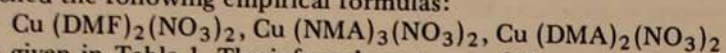
Table 2. Infrared Frequencies of Copper Complexes of N-Methylamides.

	$\nu \text{ C=O stretch}$ (free ligand) cm^{-1}	$\nu \text{ C=O stretch}$ (complex) cm^{-1}
$\text{Cu}(\text{DMF})_2(\text{NO}_3)_2$	1662	1652
$\text{Cu}(\text{DMA})_2(\text{NO}_3)_2$	1650	1600
$\text{Cu}(\text{NMA})_3(\text{NO}_3)_2$	1656	1615

Table 3. Long Wavelength Electronic Spectra of Copper Complexes of N-Methylamides.

Complex	$\lambda \text{ max}$ mk	$\nu \text{ max}$ cm^{-1}
$\text{Cu}(\text{DMF})_2(\text{NO}_3)_2$	740	13,513
$\text{Cu}(\text{DMA})_2(\text{NO}_3)_2$	754	13,263
$\text{Cu}(\text{NMA})_3(\text{NO}_3)_2$	744	13,441

see which of the two donor atoms would coordinate with a given metal ion. We prepared Cu(II) complexes of these three ligands by a previously described method (1). The elemental analysis established the following empirical formulas:



The results are given in Table 1. The infrared spectrum of these complexes show lower C=O stretching frequencies (see Table 2) for all these complexes indicating that oxygen atom is the donor atom. In the nmr spectra, the evidence of cis-trans-isomerism was still detectable which showed that the nitrogen atom was not involved in complexation. The long wavelength electronic absorption spectra are given in Table 3. All these data indicate that the bonding involved in these complexes are very similar to one another.

Literature Cited

1. Inhof, V., and R. S. Drago. 1965. Preparation and Spectral Properties of Some Alcohol Complexes of Ni(II). *Inorg. Chem.* 4(3):427-28.

Geology and Mining Section

Ground Water Development for Communities and Industries in West Virginia

Benton M. Wilmoth
Environmental Protection Agency
Wheeling, West Virginia 26003

Abstract

During the next several decades many new small communities and industries in West Virginia will need to develop water supplies and many existing communities and industries will have to consider additional sources. Such water supply problems may be solved by using the experience of others in ground water development and the history of operation of existing ground water systems.

Ground water from wells, springs, and abandoned mines supplies 301 community water systems serving about 472,000 persons. In addition, another 480,000 rural residents are supplied by private well and spring developments. Those dependent upon ground water represent about 55 percent of the State's total population.

The quantity of ground water discharged naturally from consolidated and unconsolidated aquifers greatly exceeds the quantity of water that is withdrawn by wells. In many areas, the potential for development of ground water supplies exceeds the projected industrial and community development.

Ground water is one of West Virginia's most widely distributed natural resources. It is estimated that more than 90 percent of all the available fresh water in the State is stored underground in the water-bearing rocks. The quantity of fresh ground water in storage is many thousand times larger than the combined storage of existing surface reservoirs.

The availability of sufficient supplies of water has been vital to the growth of communities and industry. Since the turn of the century, water developers in several hundred communities have shown that a relatively low cost public water supply was most frequently obtained from a ground water source. In some very favorable ground water areas, however, the resource has not been utilized to its full potential.

In 1971 the total use of ground water from all sources in the State averaged about 174 mgd. Withdrawals are somewhat larger in summer months because of the increased seasonal use of air conditioning, industrial cooling, and irrigation. Some 301 communities with a total population of 472,000 and an additional 480,000 rural residents use 65 million gallons per day (mgd). This is about 55 percent of the population that is dependent upon ground water sources (West Virginia Dept. Health, 1967).

Early ground water developments for communities and industries were mostly shallow dug wells and improved springs. Widespread drilling of deep wells for communities began in the early 1900's because of rapid increase in the number of coal mining and timbering communities. Collector sumps in aban-

doned mines have also served as a convenient source of water for more than a hundred communities. Presently 63 communities use this source of water, pumping about 4 mgd to serve 41,000 persons.

Natural springs occur throughout the State, usually on hillsides, near valley edges, and along streams. Many springs issue from fractures in sandstone and shale, because rock zones of lower permeability divert ground water toward the land surface. Extremely large springs yielding several hundred or several thousand of gallons per minute usually flow from extensive interconnected solution zones in carbonate aquifers. Twenty-four communities use springs, which includes Bluefield, White Sulphur Springs, and Charles Town. Pumpage is about 8 mgd to serve 73,000 persons.

Industrial use of ground water is generally concentrated along the major stream valleys. Total pumpage from more than 400 private industrial water facilities is about 75 mgd. The most heavily developed aquifers for industrial supply are in the unconsolidated alluvium along the Ohio River Valley and the massive sandstone aquifers of lower Pennsylvanian age in the southern and central areas of the State. In addition, approximately 8,000 private ground water systems are used by business firms, farms, dairys, schools, and churches in rural areas not served by public water supplies. The estimated total pumpage is 10 mgd. Federal, State and privately owned fish hatcheries (10 facilities) use about 13 mgd of ground water most of which is from large natural springs.

Ground water collecting in hillside mines is drained to stream channels by gravity. Some mine water is utilized as spray water in dust control in working areas and for mixing of concrete. In mines reached by vertical shaft below the local surface drainage levels, surplus mine water is drained to large sumps inside the mine and then is pumped to the land surface through boreholes to be discharged into the nearest stream. At some mines the water is pumped to a large surface reservoir or tank to be used at a coal washery, or tippie or to be distributed by gravity pressure back into the mine for various uses. Estimated ground water use for mining purposes is 10 mgd.

Irrigation of large farm crops from ground water sources is employed in only a few places. The most extensive use of ground water for irrigation is from private domestic wells on lawns, golf courses, nurseries, and other cultivated landscapes. Approximately 1 mgd of ground water was pumped for irrigation during 1971.

One important objective of the water conservation effort is to determine the quantities of water that can be obtained from various water-bearing units. In general, moderately large supplies of low-cost ground water of satisfactory quality are available in several large areas of the State.

The yield of wells depends upon the local hydrogeology. Most important is the permeability of the aquifers, but topography and the shape of the water table also have an effect. Relatively shallow wells drilled in valleys tend to produce more water than much deeper wells drilled high on hills, because in valleys the zone of fracture enlargement and weathering is more likely to be saturated by ground water. Shallow rocks on hilltops are as permeable but usually occur above the water table and therefore do not contribute to well yield.

The present depth of drilled water wells in consolidated aquifers ranges from less than 25 to more than 1,000 feet, however the average depth is only about 115 feet. Some 214 communities (population 358,000) use drilled wells for water supply. Pumpage is about 28 mgd. Many public water well systems have

been pumped daily for more than 40 years with no record of water shortage during drought periods. This indicates that the practical sustained yields of those systems have never been exceeded. Records of ground water storage show that over long periods the recharge to aquifers equals the amount of discharge. Only in heavily pumped or overdeveloped local areas or during periods of drought has discharge exceeded recharge to seriously affect storage temporarily (Wilmoth, 1965).

A highly productive water-bearing rock unit is the unconsolidated glacial outwash sand and gravel alluvium (Carlston and Graeff, 1955). These deposits border the Ohio River Valley, the lower half of the Kanawha River Valley, and a few miles upstream from the mouth of Big Sandy River, Guyandotte River, Coal River, and Little Kanawha River. The alluvium varies in width from a few hundred feet to several miles and in thickness from 40 to 150 feet.

Although these unconsolidated sand and gravel deposits constitute some of the best aquifers in the State, they underlie only about one percent of the total land area. Yields range from less than 50 to more than 900 gallons per minute (gpm) and average about 200 gpm to standard vertical screened wells. Well fields of 3 to 5 wells produce 0.5 to as much as 3 mgd of good quality water in most places. Yields of large-diameter radial collectors range from 1,000 to 3,000 gpm and single installations can produce as much as 1 to 4 mgd (Figure 1).

Consolidated bedrock aquifers underlie most of the land surface and are the

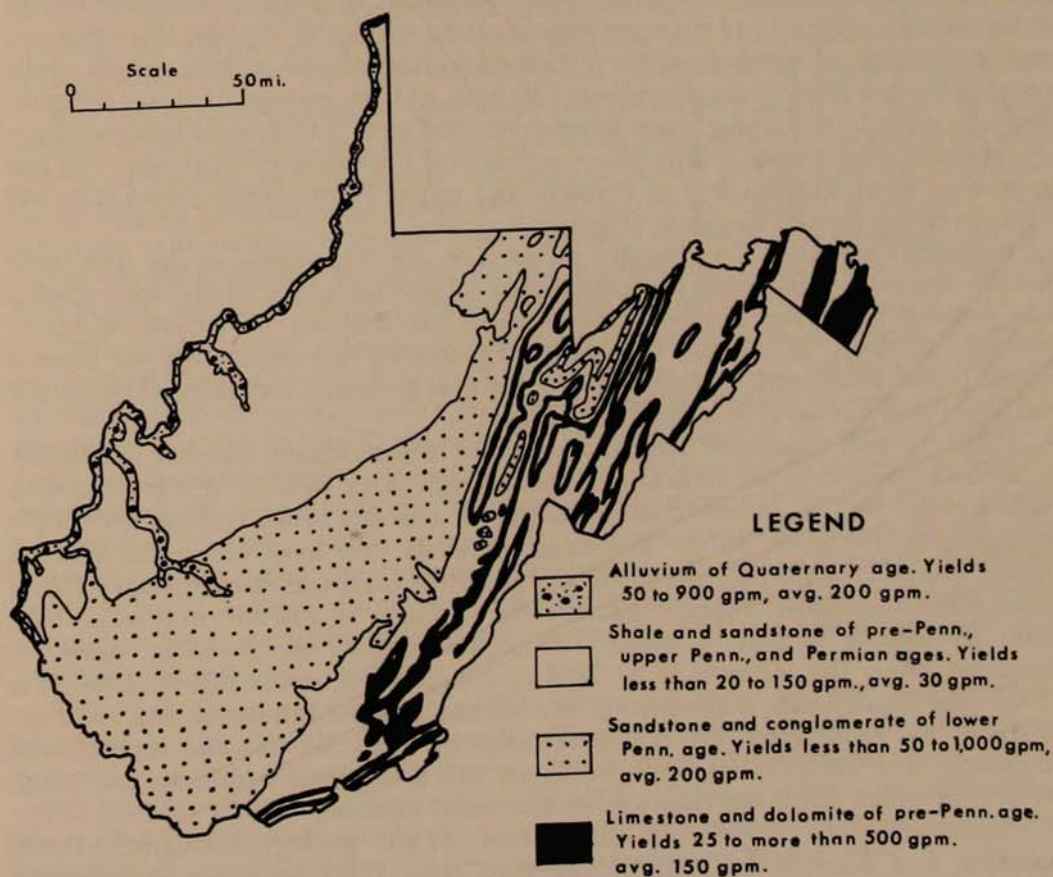


FIGURE 1. Major ground water areas of West Virginia.

principal source of water for rural domestic, farms, and businesses. A large area of predominantly sandstone aquifers of lower Pennsylvanian age extends about 200 miles through the central part of the State. The area is about 25 miles wide in the north and 50 to 75 miles wide in the south. These water-bearing rocks from oldest to youngest include the Pottsville and Allegheny Groups and the lower part of the Conemaugh Group. Yields of individual wells range from less than 50 to 1,000 gpm and average about 200 gpm (Figure 1). Supplies as large as 0.5 to 1 mgd have been developed locally from these aquifers with 3 to 5 wells (Wilmoth, 1967).

Water-bearing carbonate rocks of pre-Pennsylvanian age of the eastern part of the State have good local productive aquifers, but the water-saturated cavernous zones are very erratic requiring study and test drilling to develop moderately large supplies. Yields of individual industrial and public supply wells range from 25 to more than 500 gpm with an average of about 150 gpm. Supplies of 0.3 to 1 mgd have been developed in areas where 3 to 5 wells penetrate interconnected water-bearing cavernous zones (Figure 1).

In typical shale and interbedded sandstone areas, the uppermost or shallowest weathered beds are the most favorable aquifers. Few wells yield large supplies from deeper predominately shale zones. The ground water availability of clay shale areas, although not high, is still adequate for private rural domestic, farm, and business supplies. Most shale sections have some siliceous zones or fine-grained sandstone beds. The extent of development of near-surface fractures in these aquifers appears to be a most important factor in the storage, transmission, and availability of ground water. Yields of industrial and public supply wells range from less than 20 to more than 150 gpm with an average of about 30 gpm. Supplies of 0.1 to 0.5 mgd have been developed with 3 to 5 wells tapping zones of relatively high permeability. These aquifers of pre-Pennsylvanian age crop out in eastern West Virginia and of Permian and upper Pennsylvanian ages crop out in the western part of the State (Figure 1).

Industrial activities have locally influenced the hydrologic cycle. The most readily apparent effects are the availability of ground water where deep mining has drained overlying aquifers and reduced the amount of ground water in storage. In areas of extensive surface strip mining the availability of ground water is also drastically curtailed. The paths that ground water takes through the shallow rocks has been permanently changed.

Planning and design of large-scale ground water development in a specific location require detailed hydrologic and geologic data. Whenever it is desired to drill a water well in an untested or unstudied area the venture is usually simple prospecting. However, of the thousands of wells that have been drilled in the State, the great majority have yields adequate for rural and domestic use. This is even more impressive considering that the majority of private rural water well sites are usually limited to within 100 to 300 feet of the dwelling, dairy, or business where the water is to be used or conditioned before distribution. It is the much larger water requirements of communities and industries that are most difficult to fulfill from ground water sources. Also the possible locations of industrial and community supply wells are often confined within narrow property lines which limits the chances for successful exploration.

Water-well sites are selected on the basis of the geology, topography, economics, and convenience. All factors vary from place to place so no single technique can apply. The trained ground-water geologist applies knowledge of ground-water occurrence and water development engineering to local hydro-

geologic conditions in order to select favorable areas for prospecting. Generally, economics, convenience, and property boundaries govern selection of specific well sites. Ideally the community or industry should be concerned with aquifer development instead of simply well site location. The hydrogeologist is concerned with a scientific evaluation of the aquifer being developed to determine the most prudent pattern for development of the ground water.

Variations exist from place to place in the type of rock material penetrated, depth to water, withdrawal rates, and water quality. These variations point up the uncertainty that accompanies subsurface exploration. The hydrogeologist, however, is confident that such variations have a natural explanation, and will use the accumulated and documented experience of other scientists and drilling contractors in order to reduce the uncertainty. There is increasing realization among water well system contractors that shared information helps to decrease the uncertainty that is inherent at an untested well site. Water well data, although of not much use to the general public, is of value to the hydrogeologist who can decipher the occurrence of ground water in a much larger area than the small area where the well data were obtained.

Analyses for individual water supply systems in areas of deficient hydrogeologic data are poor substitutes for detailed study of the regional ground water hydrology. Such studies include mapping of the water-bearing formations and aquifer testing to determine the percentage of gross volume of the rock that is stored ground water and the fraction of it that can be withdrawn by wells. These studies also answer the question "Now that the well is drilled and has encountered water, what amount will it produce and how long will it sustain the yield?"

The principal problems of large-scale ground water development are the generally irregular distribution of good aquifers in consolidated rocks, and the local effects of mining on ground water availability. Although the chemical and physical quality of ground water are usually satisfactory for most ordinary uses, there are local problems such as high iron, hardness, chloride, and hydrogen sulfide. Other chemical quality problems are local pollution of aquifers by oil and gas operations, industrial wastes, domestic sewage, and mining wastes.

The character and amount of dissolved mineral matter in ground water depend chiefly on the types of rock and soluble products of rock weathering through which the ground water has flowed and the length of time of contact. Consequently the chemical character of ground water in an aquifer will vary from one area to another as well as vertically because of differences in aquifer mineralogy. Because of diverse hydrogeologic conditions ground water in the principal developed aquifers has a wide range in chemical quality in the concentrations of mineral constituents. The water ranges from soft to very hard and contains small to large amounts of dissolved minerals. Many bedrock wells penetrate two or more water-bearing rock zones so that the water produced is a composite or mixture.

In a few areas, limitations on use of ground water are imposed by poor chemical quality. Locally, high iron, hardness, chloride, or hydrogen sulfide may present problems of water treatment. These costs of treatment are of major concern in development of a particular aquifer. However, even with some treatment, the cost of finished ground water at the tap in most areas is only about one tenth to one third the cost of finished surface water at the tap.

The most widespread unsatisfactory natural constituent of fresh ground water is iron of objectionable concentrations. In some areas water of much better

chemical quality is obtained by casing off the poor quality water and tapping an alternate aquifer.

Throughout much of the western third of the State deep saline water has migrated upward and mixed with the shallow fresh water (Doll, Wilmoth, and Whetstone, 1960). Consequently beneath the major stream valleys at depths of several hundred feet salty ground water is present. Expert advice is needed when test drilling is to be done in these areas.

Solid sediment or fine suspended material is generally filtered out while moving through rock, but dissolved chemical contaminants percolate to the aquifer and move down gradient with the ground water to points of natural discharge or to pumping wells.

Contaminants in ground water move quite slowly and the dilution and dispersion are low. Velocity of movement can be as high as 1 to 10 feet per day in some aquifers to as low as 1 to 10 feet per year in other aquifers. Pollutants usually move down the natural water-level gradient or the pumping water-level gradient in similar concentrations as in the area of polluted recharge. Information on the local hydrogeology can usually provide some relief with these problems.

The slow movement of pollutants in the aquifer results in long-lasting contamination at a well. Pollution can become evident many years or decades after the initial contaminant was introduced to the aquifer. Consequently the cleaning or flushing of the contaminant from the aquifer can require an equal amount of time.

Development of the ground water resources of the State to meet future needs requires information on the sources, occurrence, history of aquifer development, and present status of ground water use. Industrial planners should select new plant sites in areas where ground water availability has been carefully evaluated.

Detailed reports on specific areas should provide a comprehensive review of the problems of ground water supply, with emphasis on future water needs and how they can best be met. The reports should also contain a description of the geology and hydrology of major aquifers, a history of ground water development and pumpage as related to water level trends, a review of ground water quality, and estimates of projected local water requirements.

Industrial and community expansion will increase ground water pumpage in certain counties. Development of new well fields and reduction of pumpage in existing well fields will help to conserve supplies in critical areas. Locating well development and pumpage over larger areas will reduce any local drawdown problems. In order that overdevelopment may be detected before depletion becomes critical, pumpage inventories should be made periodically and correlated with records of ground water storage. This should provide enough data to indicate where overdevelopment may exist and offer a basis to begin remedial work.

Literature Cited

1. Carlston, C. W., and G. D. Graeff. 1955. Ground water resources of the Ohio River Valley in West Virginia. W. Va. Geological and Econ. Surv., Morgantown, W. Va.
2. Doll, W. L., B. M. Wilmoth, and G. W. Whetstone. 1960. Water resources of Kanawha County, W. Va. Bull. 20, W. Va. Geological and Econ. Surv., Morgantown, W. Va.
3. West Virginia Department of Health. 1967. Public water supplies in West Virginia.
4. Wilmoth, B. M. 1965. Natural equilibrium in ground water storage reestablished at Charleston, W. Va. *Proc. W. Va. Acad. Sci.* 37:167-73.

5. ———. 1967. Hydraulic properties and history of development of lower Pennsylvanian aquifers. *Proc. W. Va. Acad. Sci.* 39:337-42.

Lunar Orbital Positions and Earthquake Frequency

Mary G. Hill and John R. Sievers

Division of Natural Sciences

Concord College, Athens, West Virginia 24712

Abstract

Because of the demonstrated effect of lunar attraction on the waters of the Earth's oceans, it has been suggested that there might be similar, but less obvious tidal movements of the crust of the Earth. The hypothesis presented in this paper is that the stresses resulting from the attraction of the moon in certain orbital positions are sufficient to trigger earthquakes under certain favorable conditions. An examination of over 400 earthquakes in the United States from 1949 to 1970, including only those quakes rated as 3 or more on the Richter Scale indicated that there was no periodicity of quakes in relation to orbital positions of the moon.

Introduction

The Moon, because it is so highly visible compared to other heavenly bodies in the night sky, has been of great interest to man. Its movements and phases, its eclipse and apparent changes in color have been observed and have been the subject of speculation. The Moon has been the subject of myth-building and pseudo-scientific theories, such as the familiar tradition of the "signs" of the Moon as a controlling factor in the choice of planting dates for crops.

The discovery of the relationship between the rise and fall of the oceanic tides and the orbital positions of the Moon has demonstrated that not all the beliefs concerning the power of the Moon on terrestrial phenomena are fantasy or myth. It is but natural to reason that if the Moon can cause the waters of the great oceans of the world to move, then the pull of the Moon might be strong enough to affect growing plants, animal life and even the crust of the earth.

Geophysicist, such as Kuenen, have stated that there is a rise and fall of the crust of the earth, corresponding to the tidal pattern of the oceans. However, because of the greater rigidity of the crust, this tidal movement of the crust is small compared to the ebb and flow of the oceans (Van Riper, 4). The crust can move, as is indicated by the observations of earthquakes, when the "solid" earth no longer seems to be solid, but moves much like the waves of the oceans.

Man has attempted to discover the nature and causes of earthquakes throughout much of the period of human history. For example, Aristotle stated that air under pressure in subterranean caverns escaped to cause earthquakes. Lucretius, in his *De Rerum Natura* stated that the collapse of the roofs of vast caverns underground might be the cause of quakes (Longwell, 3).

Siesmologists today attribute earthquakes to the sudden yielding of the crust of the earth to stresses. The movement resulting from this slippage may create new faults or fractures of the crust, or may cause displacement along existing faults. The contact surfaces of the fractures are usually under extreme shear stress, but the friction of the contact surfaces may provide strong resistance to movement. If the stresses continue to increase, it may overcome this friction. This is the classical "elastic rebound theory," developed by Harry Riedling Reid, after the San Francisco earthquake of 1906 (Veerhogen, 5).

Recent theory suggest that the crustal movements that result in quakes may be along the edges of large plates or "paving blocks" in the crust of the earth (Heezen, 1). The movement of these blocks not only provide a method of analysis that contributes to the understanding of continental drift, sea-floor spreading and orogeny, but also may add to the understanding of the causes of earthquakes (Le Pinchon, 1).

Any factor that may increase the stresses in the crust or reduce the resistance to slippage may contribute to the development of an earthquake. It has been suggested that ground water penetrating the crust may serve as a lubricant in the fault zone and may decrease the resistance to movement. Extensive pumping of water from underground reservoirs may reduce the weight of a part of the crust, causing a shifting of materials that may result in an earthquake. There have been attempts to control earthquakes by pumping water into the ground, to prevent this reduction in weight (Wilson, 6).

The Moon and Earthquakes

The hypothesis presented in this paper is that the gravitational attraction of the Moon may be sufficient to upset the balance between the crustal stresses and the resistance to slippage in fault zones. It is hypothecated that if other conditions are favorable, the "pull" of the Moon may trigger an earthquake. Therefore, it is suggested that there will be a tendency for earthquakes to occur during a certain period of the lunar month.

The hypothesis may be stated as: Earthquakes tend to occur with greater frequency when the Moon is in certain orbital positions.

Method of Study

Four dates in the lunar month representing orbital positions of the Moon, hereafter referred to as "events" are used in this study: Date of perigee, Age of Moon, Date of New Moon and Date of Full Moon. The dates of earthquakes were obtained from the United States Geological Survey Earthquake Reports. The study includes only quakes in the United States from 1949 to 1970, and only quakes rated as 3 or more on the Richter scale.

The dates of the lunar events were obtained from the *Nautical Almanac* for the years included. Each earthquake was identified in terms of the number of days before or after each lunar event. A frequency count was then made, to determine the number of quakes occurring during each day of the lunar month for each of the lunar events. A scatter diagram for each lunar event was prepared, to show the general pattern of distribution of earthquakes during the lunar month.

Results of the Study

An examination of the four scatter diagrams does not show any pattern that would suggest a strong central tendency. Although there are one or two days

CHART I
Frequency of Earthquakes & Perigee
1949-1970

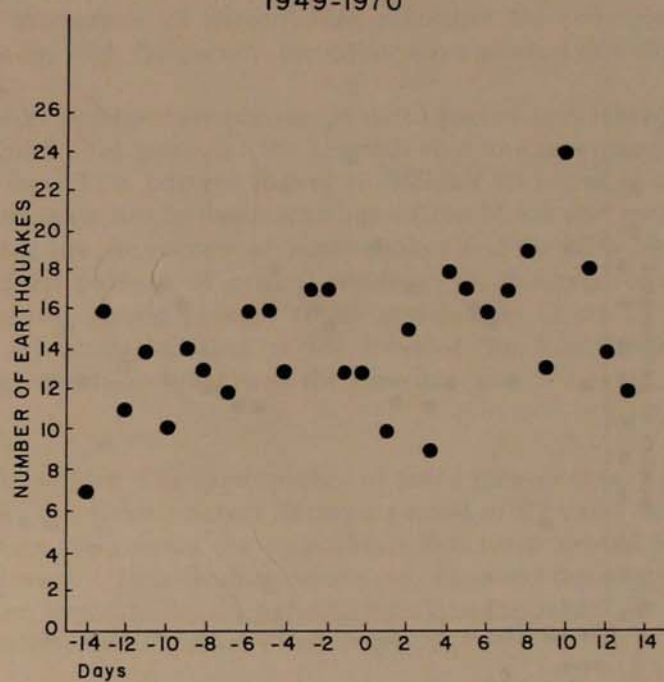


CHART II
Frequency of Earthquakes & Lunar Age
1949-1970

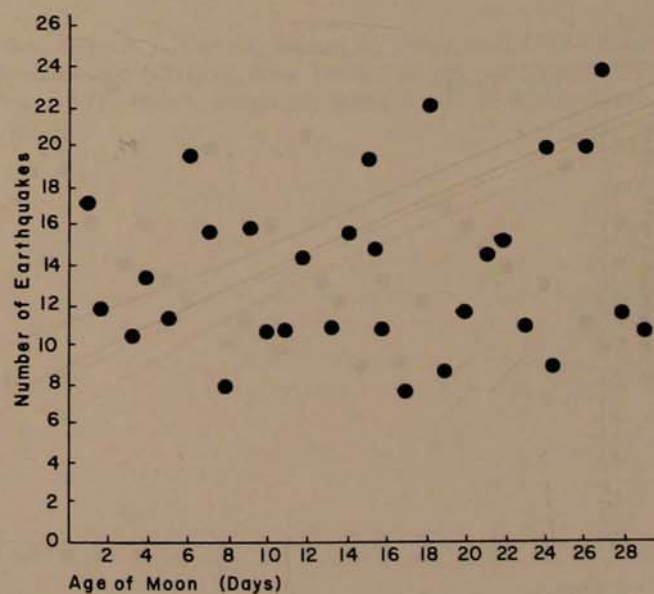


CHART III

Frequency of Earthquakes & New Moon
1949-1970

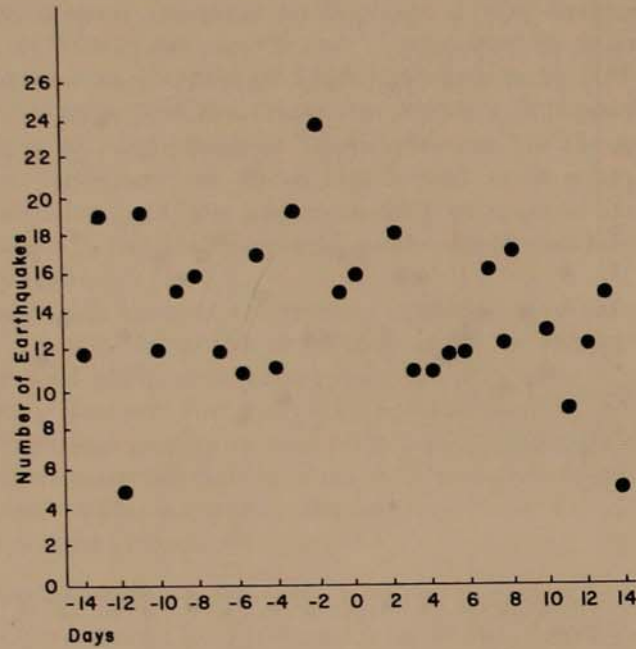
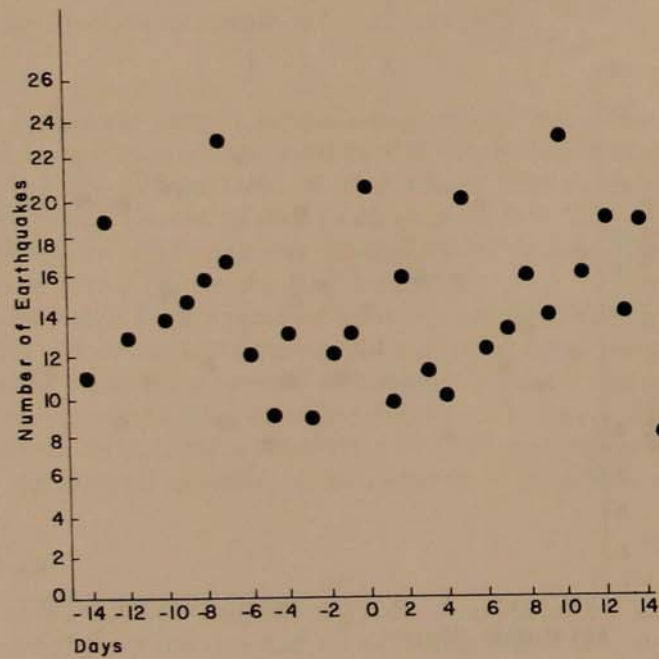


CHART IV

Frequency of Earthquakes & Full Moon
1949-1970



that may have a few more earthquakes than the mean, there does not seem to be a pattern that follows a normal curve of distribution.

For example, in examining the relationship between the time of perigee and earthquake frequency, there is no obvious pattern. It should be noted that there is a rather high frequency of earthquakes recorded for the eleventh day after perigee. There is no high frequency for other days around this time of the lunar month (Chart I).

The relationship between frequency of earthquakes and the age of the Moon seems to have three peak periods: the seventh day, the seventeenth day and the twenty-seventh day. This pattern makes it difficult to arrive at any conclusion concerning the relationship between the age of the Moon and quakes (Chart II).

The pattern for the frequency of Earthquakes and the New Moon (Chart III) indicates some faint pattern of central tendency in this relationship. However, this tendency is not strong enough to be conclusive. Chart IV indicates that there might be fewer earthquakes at the time of the Full Moon, as would be expected if there were more quakes at the New Moon.

Conclusions

The data collected for 424 earthquakes of force greater than 3 on the Richter scale occurring in the United States during a period of 22 years does not provide conclusive evidence supporting the hypothesis that lunar orbital position affects earthquake frequency. This finding seems to support the statement of Verhoogen that there seems to be no periodicity of earthquakes, for there seems to be a random distribution of quakes (Verhoogen, 5).

Literature Cited

1. Heezen, Bruce C., and Ian D. McGreagor. 1972. Riddles Chalked on the Ocean Floors. *Saturday Review*. April. 55-59.
2. Le Pichon, Xavier. 1968. Sea-floor Spreading and Continental Drift. *Journal of Geophysical Research* 73:2119-36.
3. Longwell, Chester R., Adolph Knopff, and Richard F. Flint. 1950. *Physical Geography*. Wiley and Sons, New York. 500 pp. pp. 392-400.
4. Van Riper, Joseph. 1962. *Man's Physical World*. McGraw-Hill, New York. 673 pp. pp. 556-57.
5. Verhoogen, John, Francis J. Turner, Lionel E. Weiss, and Clyde Wahrhaftig. 1970. *The Earth*. Holt, Rinehart and Winston, New York. 748 pp. pp. 228-29, 533-41, 683-94.
6. Wilson, J. Tuzo. 1972. Mao's Almanac, 3000 Years of Killer Earthquakes. *Saturday Review*. April. 60-69.

Uranium Potential of Mississippian Mauch Chunk-Pennington Groups in Virginias and Maryland

John M. Dennison

Department of Geology

University of North Carolina

Chapel Hill, North Carolina 27514

Abstract

Most commercial uranium deposits in the United States occur in fluvial sandstones. Uranium protore sandstone is characteristically arkosic or feldspathic and is usually reddish or brownish in color associated with oxidation of originally carbonaceous or pyritiferous sandstones (Adler, 1970). The ore bodies occur at the redox interface at the downward circulation limit of oxidizing groundwater. Uranium cells could occur in recent groundwater circulation systems or be formed earlier associated with regional tilting and unconformities.

The Mauch Chunk Group is mostly clastic with conspicuous reddish shales and siltstones and reddish, greenish, and gray sandstones occurring in the interval between the Greenbrier Limestone and Pottsville Group in Maryland and West Virginia. Equivalent strata between the Newman Limestone and Pottsville Group are called Pennington Formation or Group in Virginia, Kentucky, and Tennessee. From Lee County, Virginia, to Randolph County, West Virginia, the Mauch Chunk-Pennington Group is divided into the Bluefield Formation (800-1250 feet), Hinton Formation (800-1350 feet), Princeton Conglomerate (20-50 feet), and Bluestone Formation (400-800 feet). The sandstones are probably subgraywacke to graywacke and are too low in feldspar content for optimum protore. Carbonized organic debris occurs in some sandstones, and thin coals are developed from Wise County, Virginia, to Randolph County, West Virginia. Mauch Chunk sedimentation patterns show fining-upward cycles characteristic of alluvial deposition. In West Virginia a typical cycle consists from base upward of channel sandstone, reddish shale and siltstone, commonly a nodular limestone, occasional underclay, and even locally coal. Marine limestone intertongues occur especially in the lower Mauch Chunk and should provide good correlation surfaces.

In southern West Virginia, southeastern Kentucky and Virginia, the Mauch Chunk-Pennington attains its greatest thickness (maximum of 3300 feet in Mercer County, West Virginia) and is conformable with the overlying Pottsville Group. Near Bluefield, Thomas (1966) reported an angular unconformity at the top of the Bluestone Formation in the Hurricane Ridge syncline. In northern West Virginia and Maryland and on the east flank of the Cincinnati Arch an unconformity is developed which becomes more pronounced toward the craton. This unconformity separates the Kaskaskia and Absaroka Sequences of Sloss (1963), or in alternate nomenclature occurs between the Tamaroa and Absaroka Sequences of Wheeler (1963). Paleotopography indicates an earliest Pennsylvanian drainage from the craton after Mauch Chunk deposition, so uranium cells could have been established then by ground water circulating down-dip toward the southeast. Folding by the Alleghany orogeny at the end of the Paleozoic Era reversed the regional dip so that present northward ground water movement could set up uranium cells related to outcrop patterns and sandstone channels.

The Mauch Chunk strata are among the most promising rocks for uranium exploration in Maryland and West Virginia. The Pennington Group of Virginia also should be seriously examined, but in Kentucky and Tennessee the Pennington passes westward into marine shale, limestone, and dolomite beds which are unlikely to contain uranium ore. Exploratory uranium mines have tested reported shows of ore in the Mauch Chunk Formation of eastern Pennsylvania.

Literature Cited

1. Adler, H. H. 1970. Interpretations of color relations in sandstone as a guide to uranium exploration and ore genesis: in Uranium exploration geology. International Atomic Energy Agency. Vienna. pp. 331-44.
2. Sloss, L. L. 1963. Sequences in the cratonic interior of North America. *Geological Soc. America Bull.* 74:93-114.
3. Thomas, W. A. 1966. Late Mississippian folding of a syncline in the western Appalachians, West Virginia and Virginia. *Geological Soc. America Bull.* 77:473-94.
4. Wheeler, H. E. 1963. Post-Sauk and pre-Absaroka Paleozoic stratigraphic patterns in North America. *Amer. Assoc. Petroleum Geologists Bull.* 47:1497-1526.

Use of Density Measurements to Study the Thermal Conversion of Kyanite to Mullite

Dilip C. Jain and Jesse J. Brown, Jr.

Division of Minerals Engineering

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

Abstract

Density measurement was chosen as a tool to study the kinetics of kyanite to mullite conversion. The average density of kyanite was found to be 3.5410 gms/cc and of mullite after complete conversion (conversion being confirmed by x-ray diffraction, density and optical observations) to be 2.9855 gms/cc. Raw kyanite samples were heated for different lengths of time at 1200°C, 1250°C, 1300°C, 1350°C, and 1400°C, and degree of conversion was established from density measurements. There are two distinct stages in the course of transformation, the acceleratory period being dominated by the nucleation rate of the mullite phase and the deceleratory period by its growth rate, which is typical of a solid state reaction. The activation energy of the conversion in the acceleratory period was found to be 95.35 k cal. Exponential relationships are observed between time of complete conversion and temperature, and between rate of conversion and reciprocal temperature.

Mathematics, Physics and Engineering Sciences Section

A Hypothesis Regarding the Effect of Ultrasonics Upon Corrosion of Steel

H. V. Fairbanks

*Department of Chemical Engineering
West Virginia University, Morgantown 26506*

Abstract

The application of ultrasonics to steel and/or to the salt solution in which the steel is immersed was found to increase the single electrode potential of the steel. This, in turn, produced an increase in the rate of corrosion. However, it was sometimes found possible, when using high intensity ultrasonics, to raise the single electrode potential of the steel to a value such that the steel became passive, which substantially reduced the rate of corrosion.

In studies involving the effect of ultrasonics upon solid-liquid interfaces, two effects have been noted: (1) the weakening of the adherence forces at the interface² and (2) the production of microstreaming of the liquid adjacent to the interface.³ Applying this knowledge to the ultrasonic effects found in steel corrosion studies, it is conjectured that ultrasonics increases the rate of diffusion at the steel-liquid interface and thereby reduces the concentration polarization effect. Reduction of this effect normally results in an increase in the corrosion rate for the steel. However, it was found possible, under certain conditions, to produce passivity.

Equipment and Procedure

Cold rolled low carbon steel was used in conjunction with salt solutions containing 1-3% NaCl. The ultrasonic frequency used was 20 KHz with power intensity up to 2 watts per square inch applied to the electrolyte, and up to 200 watts per square inch applied to the steel rod.

The steel rod was one half inch in diameter and eight inches long. One end was threaded and screwed into the end of the acoustic horn while the other end was immersed in the electrolyte. The electrolyte was contained in a standard ultrasonic cleaning bath. Figure 1 shows a schematic sketch of the apparatus used.

The electrode potential of the corroding steel was recorded using a saturated calomel half cell as the reference cell while various intensities of ultrasonic power were introduced into the electrolyte and/or into the steel rod. With this apparatus it was also possible to study the effect of ultrasonics on the electrode potential while the steel rod was cathodically and anodically protected.

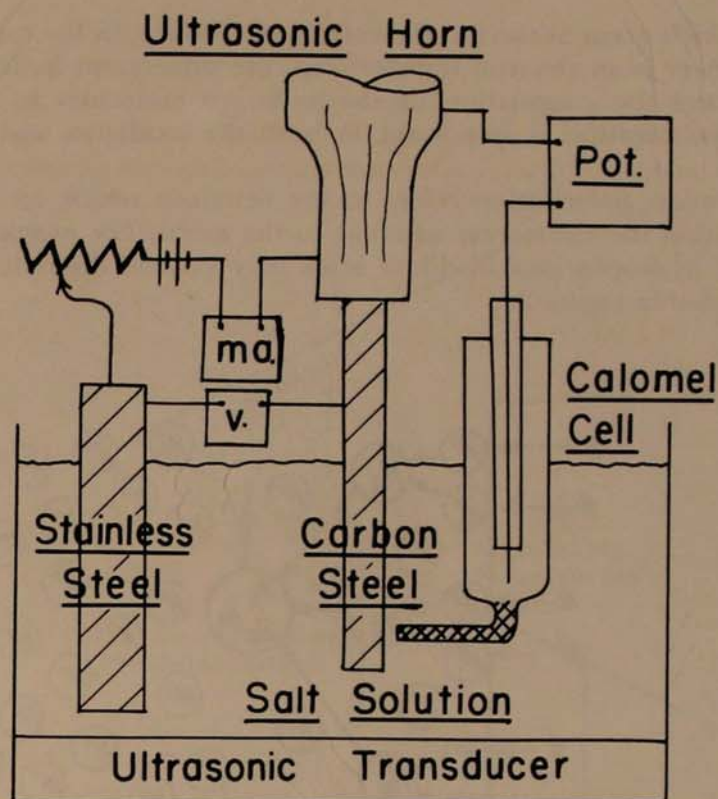
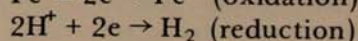
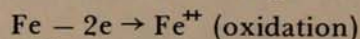
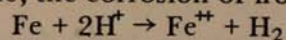


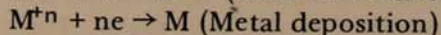
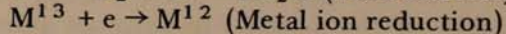
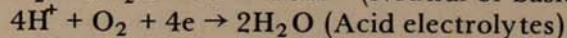
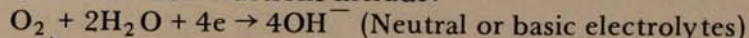
FIGURE 1. Schematic sketch of apparatus used.

Corrosion Theory

The electrochemical theory of aqueous corrosion states that any electrochemical reaction can be divided into two or more partial oxidation and reduction reactions. For example, the corrosion of iron in dilute sulfuric acid.



Other possible reduction reactions include:



The first two reactions require that oxygen be dissolved in the electrolyte. Due to the limited solubility of air in water and the lower diffusibility of molecules than ions in solution, these reactions are normally diffusion controlled.

In an electrochemical reaction there cannot be an accumulation of electrical charge. From this it follows that in the corrosion of a metal, the total rate of oxidation must equal the total rate of reduction.

The rate of an electrochemical reaction is limited by an effect called polarization. There are two types of polarization: (1) activation polarization and (2) concentration polarization.

Activation polarization refers to the processes controlling the reaction

sequences which occur at the metal-electrolyte interface. In the case of hydrogen reduction, there is an electron transfer step, the subsequent hydrogen molecule formation, and the coagulation of the hydrogen molecules to form bubbles. Activation polarization is important in both the oxidation and reduction reactions.

Concentration polarization refers to the reactions which are controlled by diffusion within the electrolyte adjacent to the metal. For example, the rate of diffusion of hydrogen ions in dilute acids may control the reduction reaction rate as depicted in Figure 2.

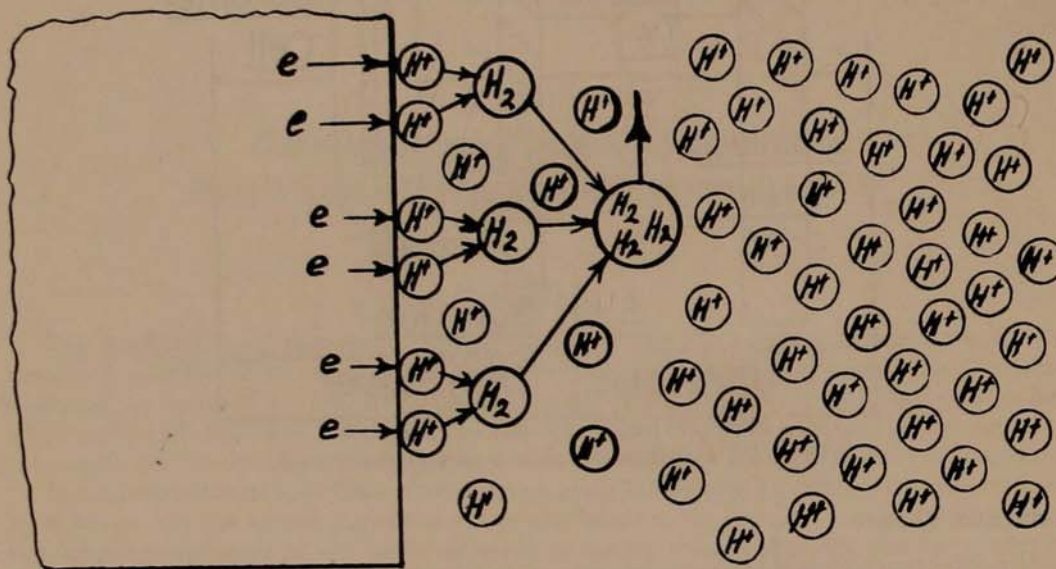


FIGURE 2. Schematic sketch showing diffusion of hydrogen ions near steel rod.

Concentration polarization is generally more important in the reduction reactions than in the oxidation reactions. Figure 3 shows a schematic sketch of a voltage versus current density curve for a reduction reaction in which there is both activation and concentration polarization.

Another important feature regarding corrosion is that several metals, including iron, exhibit a phenomenon of becoming passive under certain environmental conditions. Passivity is the ability of the material to form an adherent surface film which retards the oxidation reaction of the base metal. The effect of passivity on the corrosion rate for a metal can best be understood by a polarization curve such as shown in Figure 4.

Results

The introduction of ultrasonic energy into the corrosion system always raised the single electrode potential for the steel except when the iron was anodically protected.¹ Figure 5 shows the results obtained superimposed upon a Pourbaix corrosion diagram for iron. Figure 6 shows the effect of ultrasonic intensity upon the change of the single electrode potential for the steel.

When the steel was cathodically protected, ultrasonics was found capable of nullifying the protection provided by the impressed voltage. On the other hand,

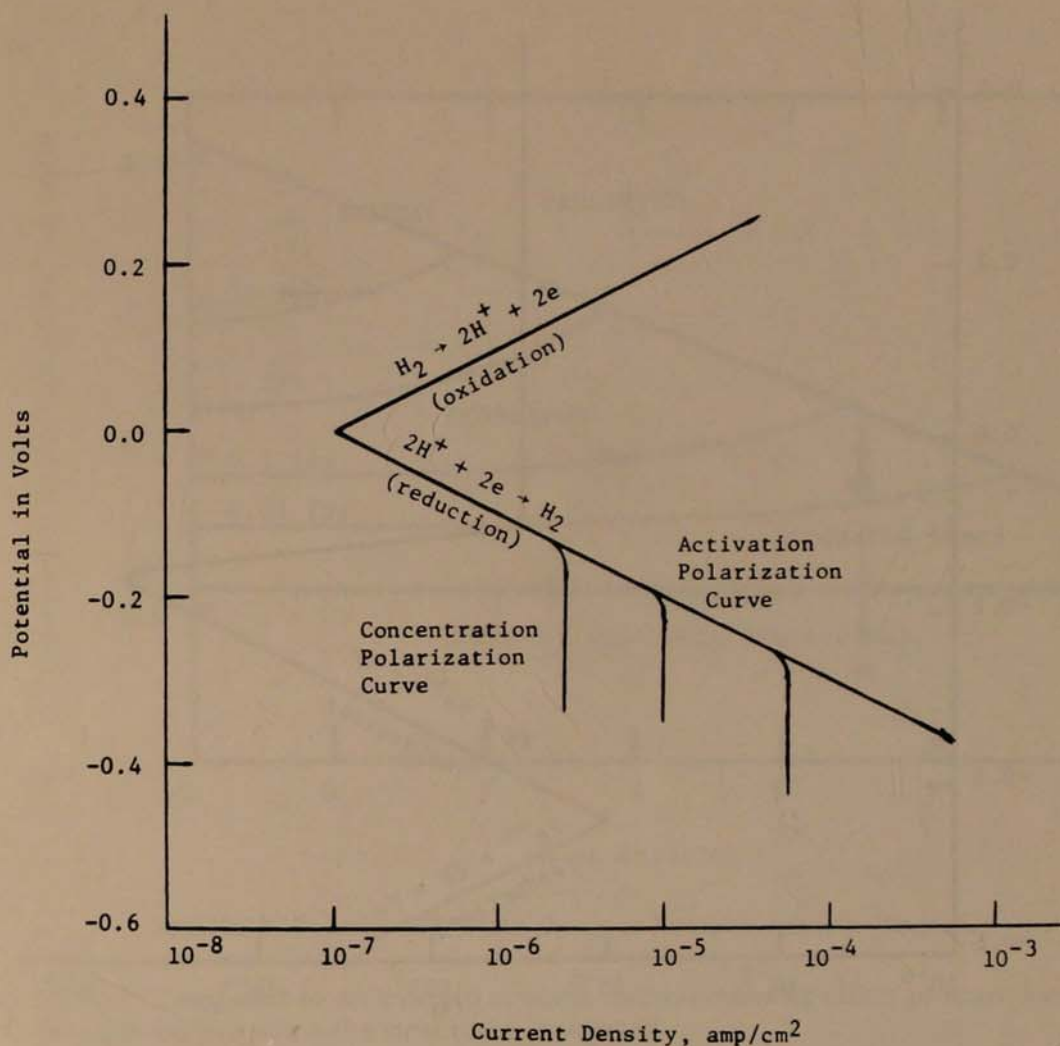


FIGURE 3. Schematic sketch of a polarization curve for a reduction reaction showing both activation and concentration polarization.

the introduction of ultrasonics was found to have very little, if any, effect on the steel's single electrode potential when it was anodically protected.

Hypothesis

No Corrosion Protection

With the corrosion system used in this study, it is conjectured that the reduction reactions were primarily controlled by the concentration polarization. If this is true, then the addition of ultrasonics into the system must be capable of increasing the diffusion processes within the electrolyte near the steel rod. Increasing the rate of diffusion would reduce the concentration polarization and thereby cause a corresponding rise in the single electrode potential of the steel.

It seems apparent that introducing ultrasonics directly into the main body of the electrolyte, from the bottom of the tank in this case, would be capable of promoting the required diffusion within the electrolyte. W. E. Rowe and W. L. Nyborg³ reported that insonation of an electrode produces an acoustic stream-

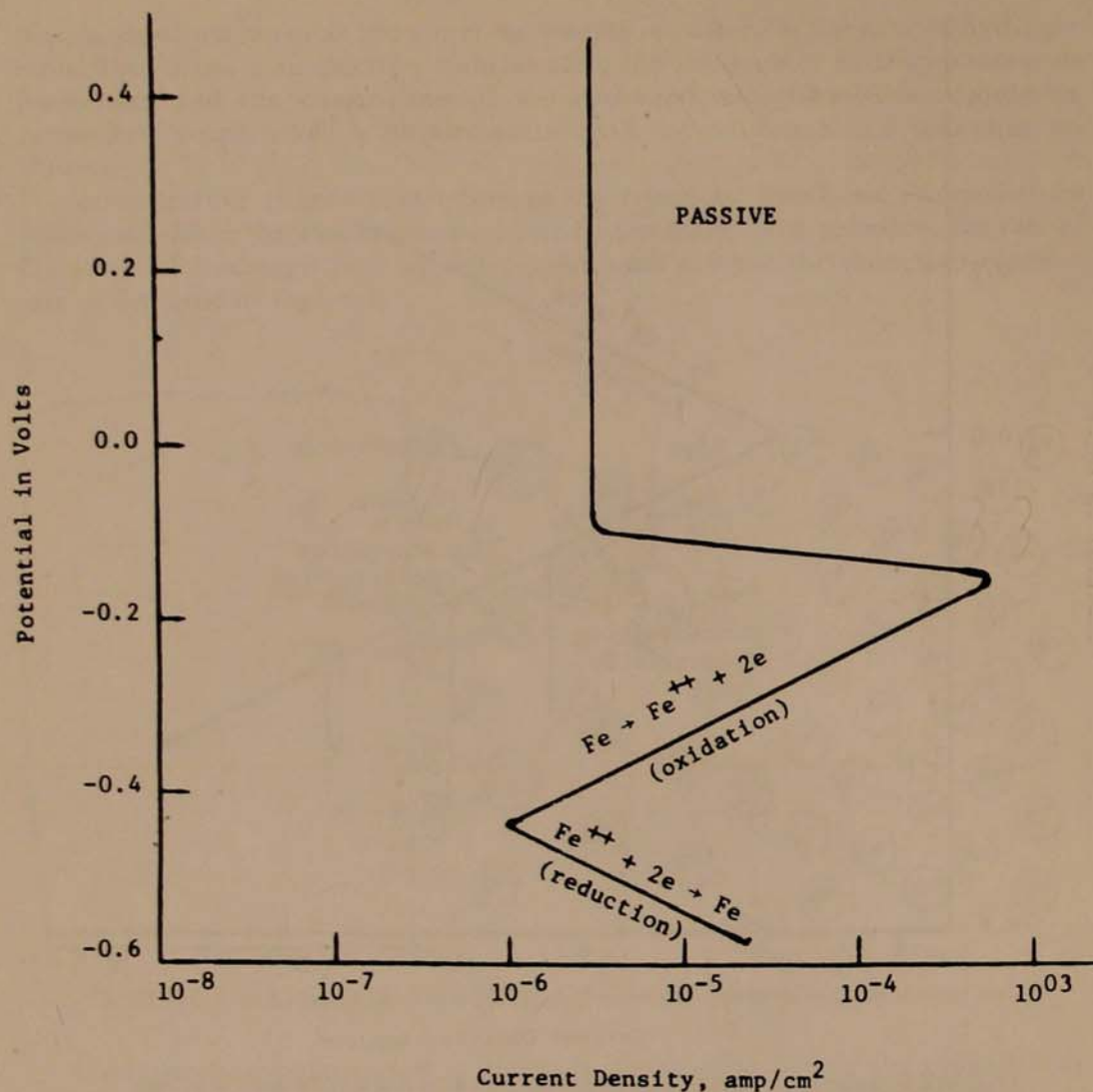


FIGURE 4. Schematic sketch of a polarization curve showing passivity.

ing of the electrolyte near the surface of the electrode. Therefore, the introduction of ultrasonics either into the electrolyte or into the steel rod should produce the same effect.

Figure 7, depicts the results using the above hypothesis which gives good agreement with the results obtained. It can be seen that as concentration polarization is decreased, the intersection of the hydrogen reduction curve with the oxidation curve occurs at higher current densities. This means increased rate of corrosion. However, if the reduction reaction produces hydroxyl ions, as shown by the upper reduction reaction curve, it is possible to produce passivity in the steel. This reaction requires that dissolved oxygen be present in the electrolyte.

Referring to Figure 6, it is noted that over 100 times the amount of ultrasonic power is required to be introduced into the steel rod than that required to be introduced into the electrolyte to produce the same change in the steel's single electrode potential. This is thought to be due to the ease of producing a direct mixing effect in the electrolyte when it is insonated from the bottom of

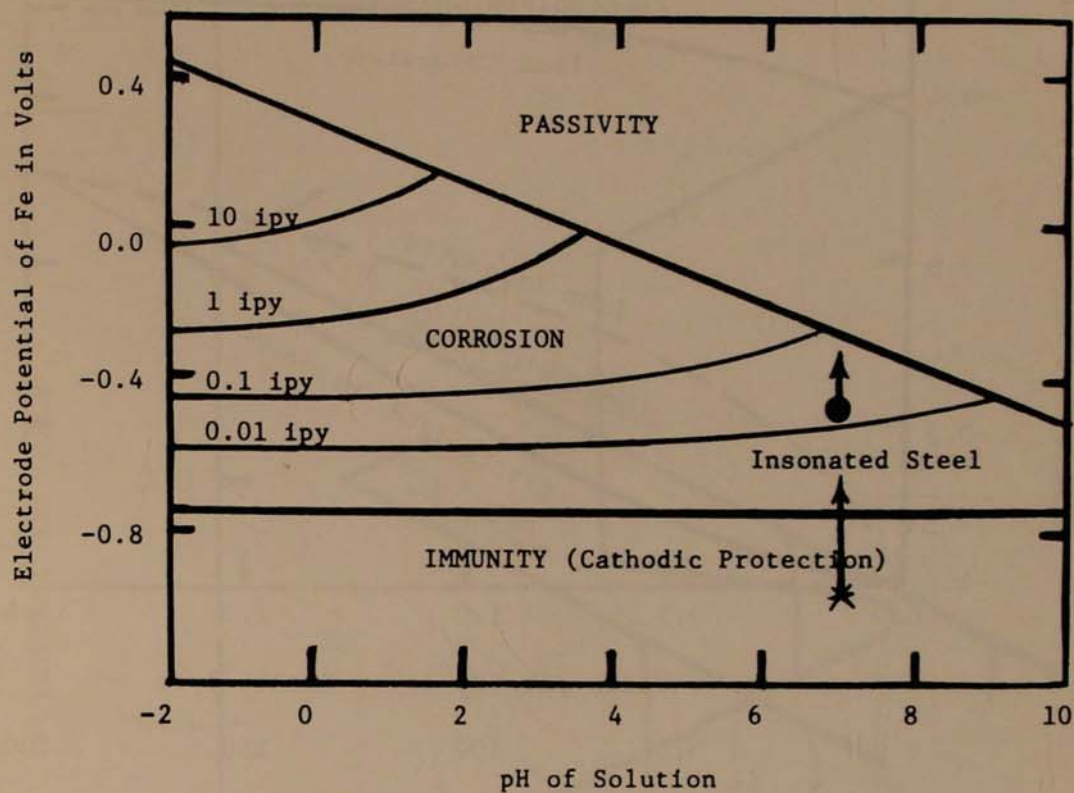


FIGURE 5. Experimental results shown on Pourbaix corrosion diagram.

the bath compared to an induced acoustic micro-streaming effect produced near the steel surface when the steel rod is insonated.

Cathodic Protection

Referring again to Figure 6, it is interesting to note that insonation of the steel rod during cathodic protection was more effective in changing the electrode potential at the lower ultrasonic intensities than it was for the steel rod not cathodically protected. It is assumed that activation polarization may also be affected by insonation in which case insonation of the steel rod directly affects the metal-electrolyte interface while insonation of the electrolyte produces a more indirect effect.

It is hypothesized that the introduction of ultrasonics into the steel rod affects both concentration and activation polarization. Reduction of these effects would reduce the resistance of the half cell containing the steel rod. This could then cause a reduction of the steel's single electrode potential as measured by the reference saturated calomel half cell.

An explanation as to the reduction of the activation polarization by ultrasonics is based on the conjecture that the introduction of ultrasonics weakens the adherence bonds of the hydrogen atoms at the steel surface interface.² If this is true, the rate of hydrogen molecule formation and subsequent bubble formation will be increased; thereby, decreasing the activation polarization.

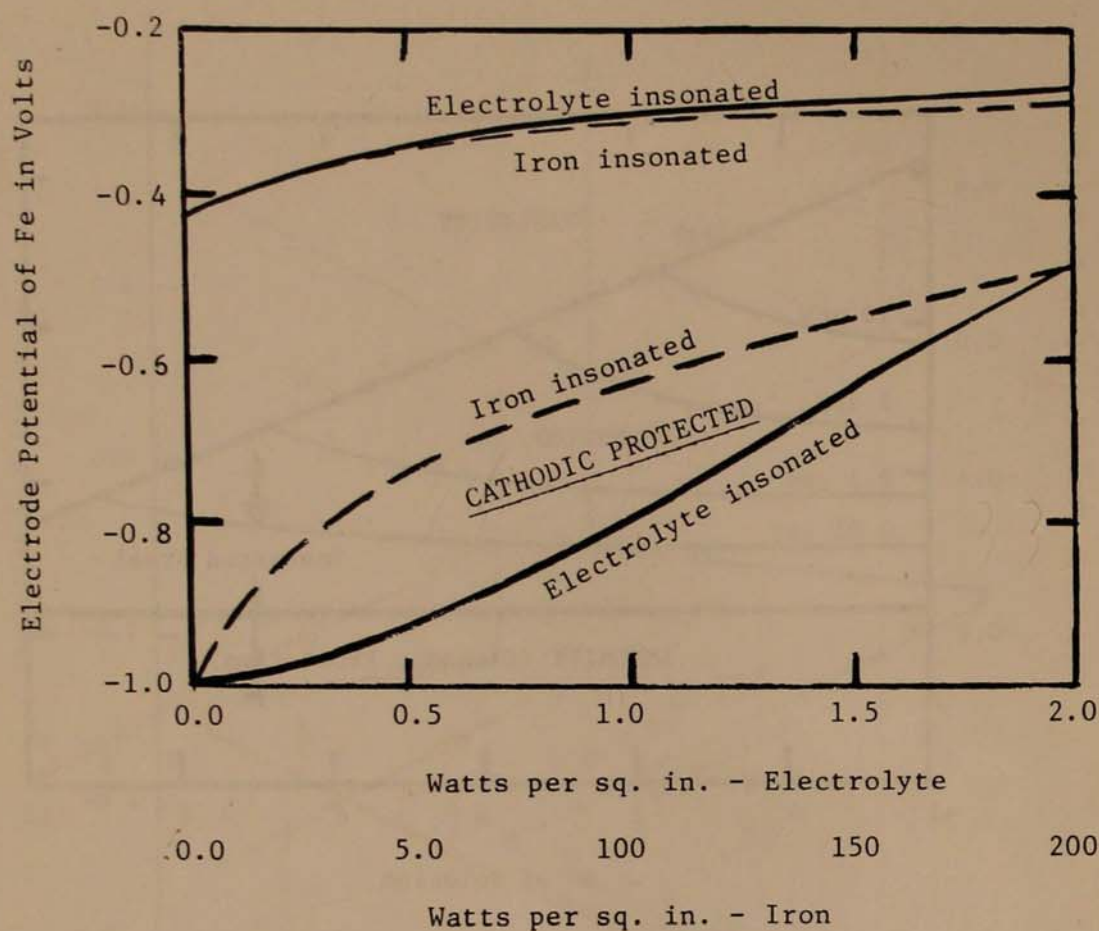


FIGURE 6. Results showing effect of ultrasonic intensity upon the single electrode potential of steel.

Anodic Protection

In anodic protection, the controlling factor appears to be the passivity film which is produced on the steel surface. The formation of this film appears to be aided by the application of ultrasonics into the corrosion system. Therefore, no apparent change is noted when an anodically protected steel rod or its electrolyte is insonated.

Conclusions

It is hypothesized that the introduction of ultrasonics into a corrosion system produces two effects:

1. to increase the diffusion rates of the processes taking place within the electrolyte adjacent to the metal-liquid interface, thereby decreasing the effect of concentration polarization.
2. to weaken the interfacial bonds between the surface of the corroding metal and the electrolyte, thereby decreasing the activation polarization.

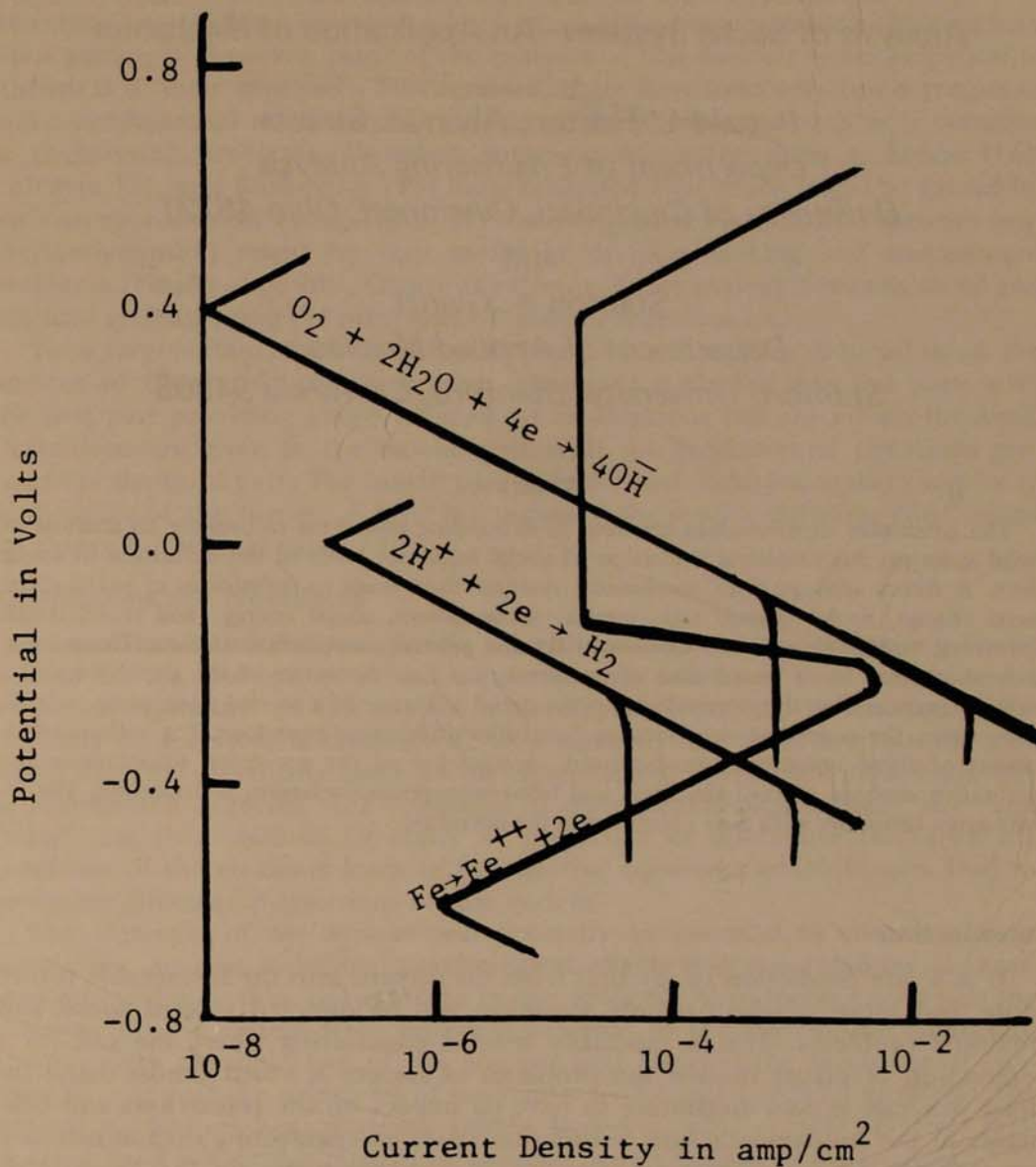


FIGURE 7. Schematic sketch showing possible oxidation-reduction polarization curves with mild steel immersed in 1-3% salt solution.

Literature Cited

1. Fairbanks, H. V. 1969. Effect of Acoustics on Corrosion of Steel. *Metals Engineering Quarterly* 62:50-52.
2. Fairbanks, H. V., and W. I. Chen. 1971. Ultrasonic Acceleration of Liquid Flow through Porous Media. *A.I.Ch.E. Sonochemical Engineering Symposium Series* 67:108-16.
3. Rowe, W. E., and Nyborg, W. L. 1966. Changes in an Electrode Process Brought about by Small-Scale Acoustic Streaming. *Journal of the Acoustical Society of America* 39:965-71.

Analysis of Social Systems—An Application of Mechanics

Ronald L. Huston, Alvin M. Strauss

Department of Engineering Analysis

University of Cincinnati, Cincinnati, Ohio 45221

and

Stanton A. Glantz

Department of Applied Mechanics

Stanford University, Stanford, California 94305

Abstract

The principles of mechanics are used in developing equations to provide an analysis of social systems. An empirical definition of social influence leads to the definition of social force. A direct analogy with mechanical systems then leads to definitions of social state, social change, social change rate, inertia, social power, social energy, and social stress. Governing equations are then developed from a general constitutive relation. These equations show that for a broad class of problems, the time derivative of the social state of a social element is directly proportional to the social influence of a second element upon it. In many cases, the governing equations are first order differential equations. The various implications of these equations are discussed. Application of the governing equations in the qualitative analysis of civil disorders and labor-management relations is presented. The results agree favorably with data presented in the literature.

Introduction

It is a safe prediction to say that from the present into the foreseeable future more and more of the nation's attention will be directed toward social and domestic problems. This is especially true in engineering where the call for a redirection of effort toward the problems of society is heard almost daily. Indeed this call is now beginning to have its impact on the researchers and educators in the fundamental and foundation fields of engineering such as mechanics and the other engineering sciences. In a recent paper on the "Future of Applied Mechanics," Howard Emmons (5) states that "... the urgent technical problems of engineering and the environment would greatly benefit from a major effort of the old methods of Applied Mechanics bringing in new laws of materials and new empirical facts as needed." This present paper is written to introduce and develop the concept of applying the principles of analytical mechanics with the societal problems of group interaction pertaining to such areas as civil disorders, labor-management relations, and minority political confrontations.

Attempts to provide analytical analyses of these particular problems are, of course, not new. Indeed, social scientists and behavioral psychologists have been gathering and interpreting data for a long time. In 1931 Ogburn (11) edited a volume on social changes containing many facts about a variety of social conditions. In 1947, Rashevsky (14) presented his (now classical) mathematical treatise on human relations. Also in 1947 Rapoport (12, 13) published two papers on the mathematics of motivational interaction. In more recent years the

literature on social analyses has greatly expanded as large quantities of data have been gathered. However, most of the analyses of this data are either empirical or statistical in their approach. Furthermore, there have been very few attempts to make fundamental mathematical models of the phenomena such as is common in engineering problems. However, some recent writers such as Simon (16), Coleman (3), and Rashevsky (15) have suggested that much might be gained by such an approach. In 1968, Tribus (17) also suggested that physical theories (e.g. thermodynamics) might be very useful in decision making and management problems. Finally, in 1969, Glantz (6) drew a direct analogy between social and physical systems using the principles of analytical mechanics.

To a large extent, the research associated with this paper is based upon the notions of Glantz (6) and these other writers. It is divided into five parts with the first part providing a discussion of the assumptions and procedures involved. Definitions are given in the second part with the fundamental equations generated in the third part. The fourth part presents two illustrations or examples of application of the theory. A brief discussion of the results and some conclusions are drawn in the final part.

Assumptions and Procedures

Institutions, societies, or groups of people form the basic elements to be studied in the analysis. A set of these elements is treated as a system and a mathematical model of this system is developed. Next, the interaction of the elements of a system is established. It is assumed that these interactions arise solely from the sustenance needs of the elements and that these interactions may be represented as forces. The condition of the elements such as their "size" and "state" are then defined. A study of the effect of interactive forces on the condition of the elements leads to constitutive equations which in turn lead to governing differential equations for the system.

The elements of the system will generally be assumed to contain a large population, so that individual psychological effects and abnormalities are averaged out and may thus be neglected in the analysis. Also, forces exerted on the elements of the system from elements external to the system, are neglected. Finally, since the objective of the analysis is to develop the fundamental concepts of applying the principles of mechanics with human societal problems, the systems studied are kept relatively simple. However, more complex systems may be considered in a similar manner by a simple generalization of the analysis.

Definitions

To exist and function, an element needs to be supported and maintained. Therefore, define *sustenance* as that which is required for a system element to exist and function. Sustenance can take many forms. It can be money, manpower, energy, material, affection, lack of hostility, etc. Often an element will require a variety of sustenances to exist, but primarily a sustenance is needed to form a given function.

If two elements are interacting, their interaction is a function of the sustenance required by each element. Indeed, in this interaction, the elements influence each other in direct proportion to the sustenance involved. Hence, the *influence* I exerted by element A on element B is defined as:

$$I_{A/B} = N_B (A_A / \sum_{j=1}^n A_j) \quad (1)$$

where N_B is the sustenance needed by B, A_A is the sustenance "available" from A and $\sum A_j$ is the sustenance available from all sources (including A and B). The "availability" involves the ease of attainment. For example, if A has a large amount of sustenance needed by B, but if A also is very reluctant to release it, it is not readily available to B and A_A is very small.

From Eq. (1), it is seen that the dimensions of influence are the same as sustenance. Also, if the sustenance available from A is zero, A has no influence over B. At the other extreme, if A is the only source of sustenance for B, the influence of A on B is the sustenance need of B.

Let ϕ represent the *net influence* or *influence difference* between A and B. That is define ϕ as:

$$\phi_{A/B} = I_{A/B} - I_{B/A} \quad (2)$$

A change in this influence difference between A and B would represent a change in the interaction between A and B. Hence, define the *social force* or simply the *force* exerted by A on B as:

$$F_{A/B} = \frac{d\phi_{A/B}}{dt} \quad (3)$$

Then $F_{A/B} = -F_{B/A}$ and force has the dimensions sustenance per unit time. Also, the influence difference is like a "potential" for exerting force. To obtain more insight regarding the nature of the social force, consider the following simple illustration: Suppose A and B are the only sources of sustenance for B and that N_B , A_B , and $I_{A/B}$ are constant. Then Eqs. (1) and (2) lead to:

$$F_{A/B} = [N_B A_B / (A_A + A_B)^2] dA_A / dt \quad (4)$$

Similarly, if N_B , A_A , and $I_{B/A}$ are constant, $F_{A/B}$ becomes:

$$F_{A/B} = -[N_B A_A / (A_A + A_B)^2] dA_B / dt \quad (5)$$

Equation (6) shows that with N_B , A_B and $I_{B/A}$ constant, the force of A on B is directly proportional to dA_A/dt . That is, A can increase (or decrease) its force on B by increasing (or decreasing) A_A the availability of its sustenance. Similarly, Eq. (6) shows that with N_B , A_A , $I_{B/A}$ constant the force of A on B is directly proportional to the negative of dA_B/dt . That is, B can decrease (or increase) the force of A by increasing (or decreasing) A_B the availability of its own sustenance.

The *mass* or *inertia* m_A of an element is defined simply as the size or population of the element. The mass of an element may usually be considered as constant, but there may be several cases where it is appropriate to let the mass be a variable.

The *social state* or *state* s of an element is defined to be the condition or configuration of the element measured with respect to some reference configuration. The state is in general a function of the mass, sustenance need, and self sustenance availability, that is; $s_A = s_A(m_A, N_A, A_A)$.

The *social change* or simply the *change* c of an element is defined as the time rate of change of s . That is:

$$c_A = ds_A/dt \quad (6)$$

A direct mechanical analogy now leads to four additional definitions which will be useful in the sequel. First, the time rate of change of C_A is defined (like acceleration) as R_A , the *change rate* of A :

$$R_A = \frac{dC_A}{dt} = \frac{d^2S_A}{dt^2} \quad (7)$$

Next, the *social energy* of A , E_A is defined as:

$$E_A = \frac{1}{2}m_A(C_A)^2 \quad (8)$$

Thirdly, the *power* $P_{A/B}$ of A over B is defined as:

$$P_{A/B} = F_{A/B}C_B \quad (9)$$

Finally, the *social stress* $\sigma_{A/B}$ of A on B is defined as:

$$\sigma_{A/B} = F_{A/B}/m_B \quad (10)$$

Governing Equations

Governing differential equations describing the behavior of the system can be written upon the establishment of a constitutive law relating the social force to the social state, social change, social change rate, and the mass. In general, such a law will have the form

$$F_{A/B} = F(S_A, S_B, C_A, C_B, R_A, R_B, m_A, m_B) \quad (11)$$

where F is a general history dependent functional which may involve time histories (integration) over the variables.

As an illustration of a special case of Eq. (10), consider the linear Newtonian relation:

$$F_{A/B} = \kappa m_B R_B \quad (12)$$

where κ is a constant. This relation satisfies the intuitive requirement that the rate of social change of an element is directly proportional to the social force exerted upon it and inversely proportional to its size. That is, the social change rate is directly proportional to the social stress.

In many situations the mass m_B may be considered constant. In these cases Eq. (12) may be integrated through use of Eqs. (2), (3), and (7) leading to:

$$I_{A/B} - I_{B/A} = \kappa m_B C_B + K \quad (13)$$

where K is an integration constant. Using Eq. (6) to eliminate C_B leads to the expression

$$\kappa m_B \frac{ds_B}{dt} - I_{A/B} + I_{B/A} - K = 0 \quad (14)$$

Hence, in this case, the governing equation is first order in S_B .

As a second illustration of a constitutive law, consider the case where S_A, C_A, R_A, S_B, C_B , and R_B are functions of n other variables $q_r (r=1, \dots, n)$ which are, in turn, functions of t . $S_A, C_A, R_A, S_B, C_B, R_B$, and $F_{A/B}$ might now be considered as vector functions. A Lagrangian formulation of the constitutive law then leads to the n equation:

$$\frac{d}{dt} \frac{\partial E_B}{\partial \dot{q}_r} - \frac{\partial E_B}{\partial q_r} = F_{Br} \quad r=1, \dots, n \quad (15)$$

where E_B is the social energy as defined by Eq. (8) and where F_{Br} is the generalized social force on B defined as:

$$F_{Br} = F_{A/B} \frac{\partial C_B}{\partial \dot{q}_r} \quad (16)$$

Following Volterra (18), it is possible to include hereditary or history dependent effects by modifying the Eqs. (15) to the form:

$$\frac{d}{dt} \left(\frac{\partial E_B}{\partial \dot{q}_r} \right) - \frac{\partial E_B}{\partial q_r} = F_{Br} - \sum_{s=1}^n \int_{-\infty}^t \gamma_{rs}(t, \tau) q_s(\tau) d\tau \quad (17)$$

where $\gamma_{rs} (r, s=1, \dots, n)$ is a "history" function determined by the prior behavior of B .

Application

To apply these ideas to specific social phenomena it is necessary to adapt the definitions to the particular system being studied. In this regard, there are a number of studies available which are helpful. For example Simon (16) and Kuhn (8) provide information on system modelling. Bredemeier and Stephenson (2) and Berelson and Steiner (1) present a comprehensive analysis on social systems and human behavior from a psychological viewpoint. Finally, an extensive literature summary on influence and persuasion is found in the work of McGinnies (9).

In this section the foregoing ideas are considered in two specific situations. These situations are chosen simply as examples to illustrate elementary application of the theoretical development. In both cases, it is convenient to use the

singularity functions which are often applied in structural mechanics. (See for example, Crandall and Dahl (4).)

Examples: Civil Disorders

Consider a model with two elements: community residents Q and the riot squad or police P . Consider especially P . Assume that the need of P and hence the sustenance of P is order within the community—that is, order of Q . (This is an over-simplification, but it is chosen simply as a first approximation to illustrate the method.) Assume further that Q is the only source of order, disorder within the model. Hence, by Eq. (1) the influence of Q over P is:

$$I_{Q/P} = N_P \quad (18)$$

Now, if there is a small civil disorder within a community, the sustenance need of P (order) increases sharply. Figure 1 illustrates this, where two minor disorders are shown. (This is typical of the disorders studied in the Report of the National Advisory Commission on Civil Disorders, (10).) Let m_P the size or mass of P (the total police force including off-duty policemen), be constant, and let s_P the state of P , be the number of policemen on active duty. Assume further that the influence of the police over the residents $I_{P/Q}$ is approximately constant in the initial stages of the disorder. Equations (6), (13), and (18) then lead to:

$$s_P = (\kappa/m_P) \int N_P dt + C_0 t + s_0$$

where C_0 and S_0 are constants. These constants represent the initial social change rate and the initial social state respectively. If N_P is as shown in Figure 1 and these disorders are treated as the singularity impulses, s_P takes the form shown in Figure 2 where the constants C_0 and s_0 have been taken as zero satisfying appropriate initial conditions. This result agrees with data presented in the Kerner Report (10).

Example: Labor-Management Relations

Consider a second example again containing two elements: labor L and management M . Consider specifically L . Let the sustenance of L be compensation (from M) for work performed, and assume that M is the only source of compensation for L . Assume further that over a period of time (years) there is a general uniform inflation and a general uniform rise in living standards. N_L will therefore increase uniformly as shown in Figure 3.

Suppose that L and M are bound by periodic contracts. Suppose further that the compensation sustenance by M to L increases periodically as the contracts are renewed as shown in Figure 4. Hence, the net sustenance need of L is the difference in the curves in Figures 3 and 4. This is shown in Figure 5.

Since M is the only sustenance source of L , Eq. (1) becomes:

$$I_{M/L} = N_L \quad (20)$$

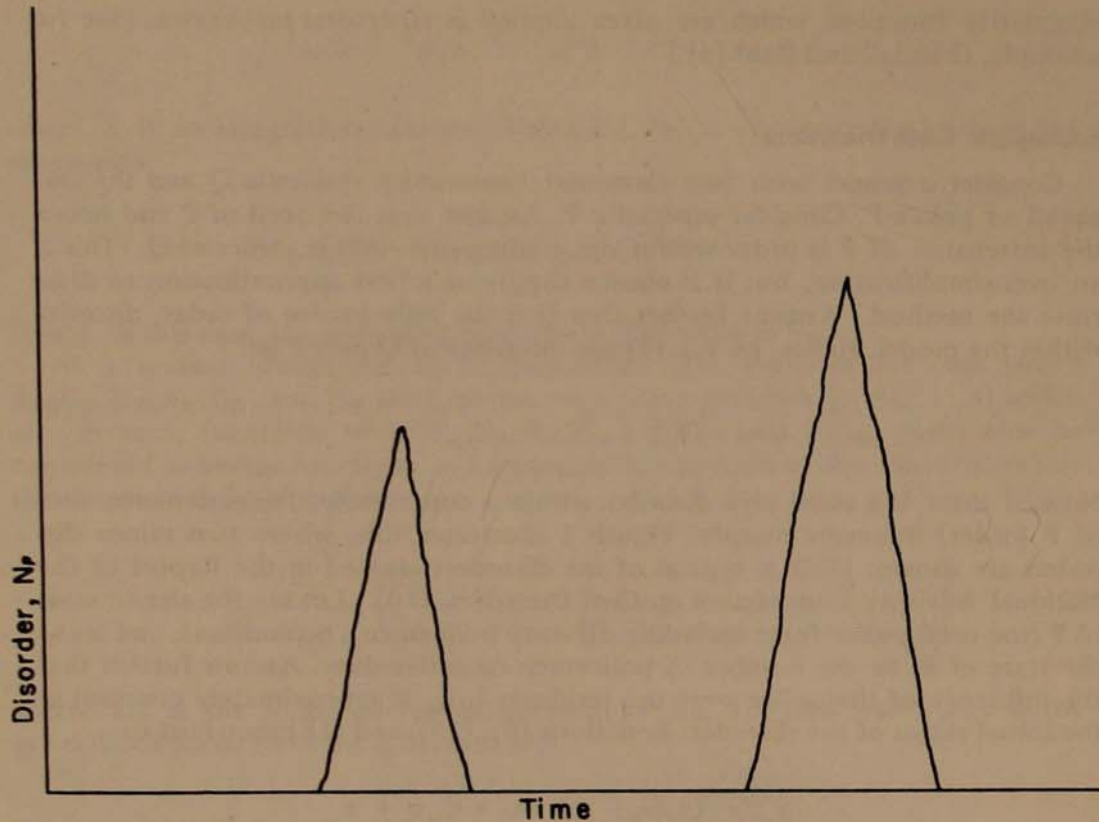


FIGURE 1. Civil disorders.

Assuming, m_L and $I_{L/m}$ are constant, Eqs. (6), (13) and (20) lead to:

$$s_L = -(\kappa/m_L) \int N_L dt + C_0 t + s_0 \quad (21)$$

where as before C_0 and s_0 are constants determined by initial conditions. The minus sign is inserted so that s_L increases positively as the provided sustenance increases. Figure 6 presents a qualitative description of this result, where C_0 and s_0 are again taken as zero by assuming zero initial social change rate and social state for L.

Perhaps the most interesting question arising in labor-management relations are those concerning strikes. Unfortunately, the simple analysis presented here is not comprehensive enough to adequately predict strikes, but a few remarks can nevertheless be made. First, the analysis covers a much larger time interval than that usually associated with strikes. Hence, a much shorter interval must be chosen for a strike analysis. Secondly, if a strike is to occur, it seems that at least two conditions must be met: (1) a serious dissatisfaction by L with M's proposed compensation and (2) an unwillingness by M to increase the compensation sufficiently to satisfy L. (Strikes could, of course, occur due to other reasons such as poor working conditions, grievances, etc., but these are neglected here.) A simultaneous analysis of both L and M is therefore needed. Third, one could propose that L is inclined to strike when N_L (Figure 5) reaches a certain level or when s_L (Figure 6) dips below a certain level. If this is a valid proposition, earlier contract renewal or discussions could be used to avoid strikes. (This is a tech-

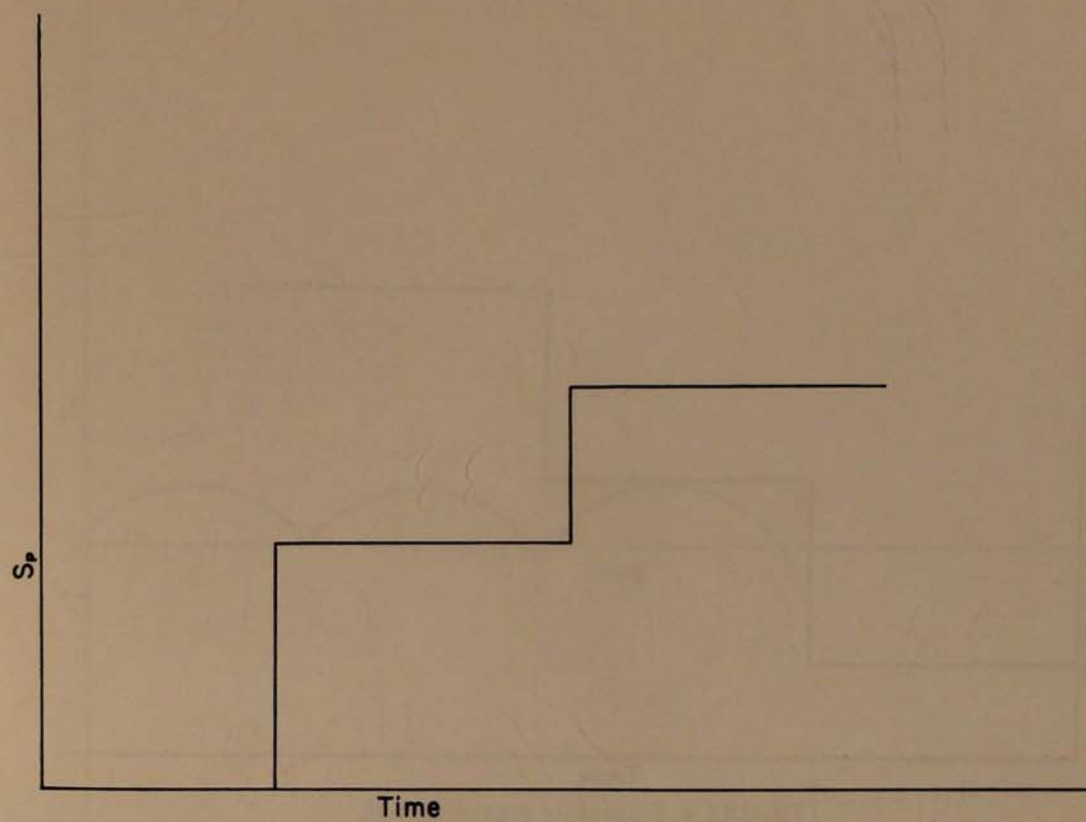


FIGURE 2. State of P.

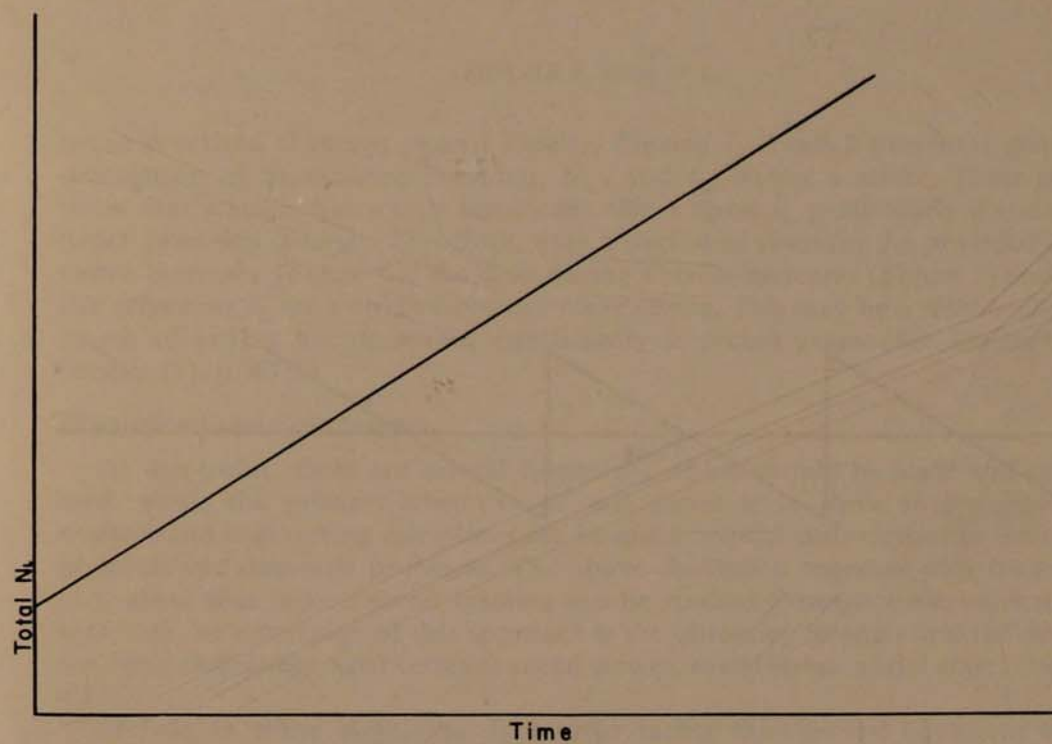


FIGURE 3. Total sustenance need of L.

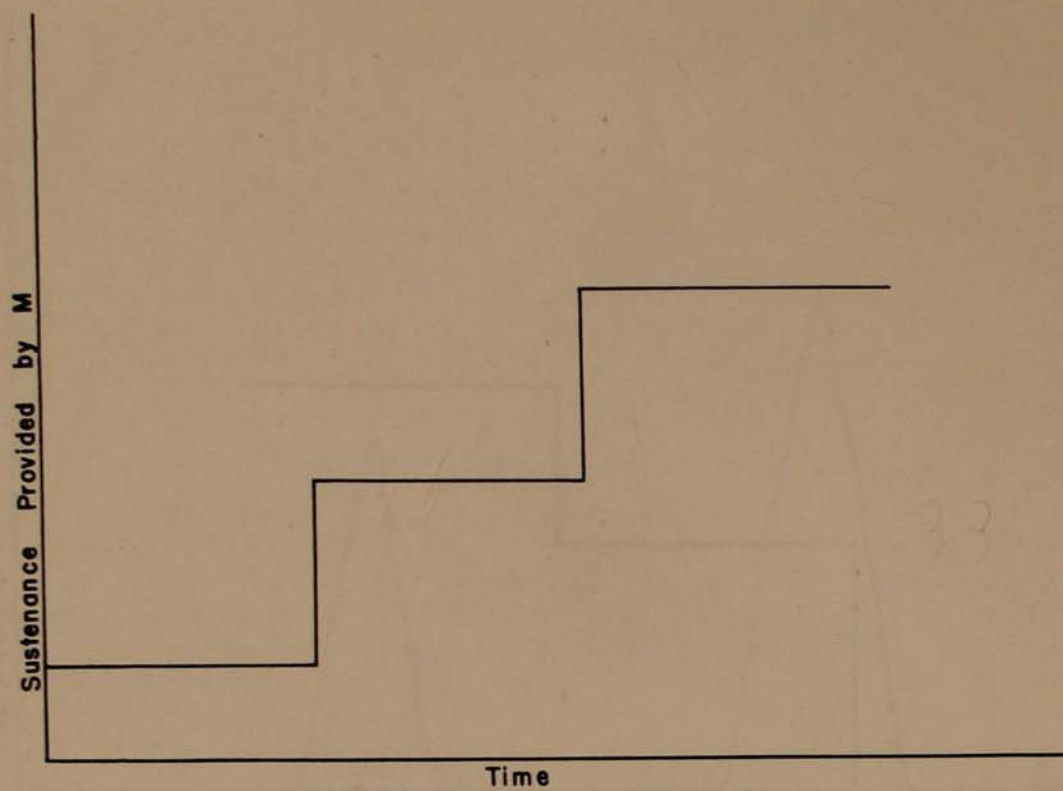


FIGURE 4. Sustenance provided by M.

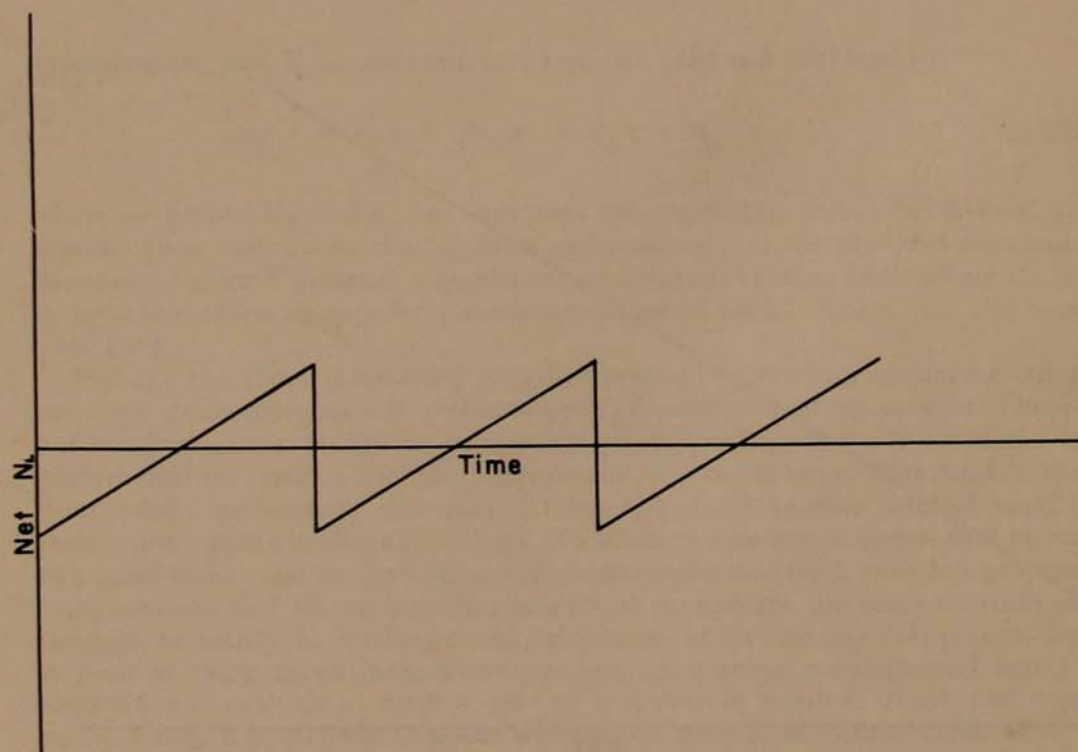


FIGURE 5. Net sustenance need of L, N_L .

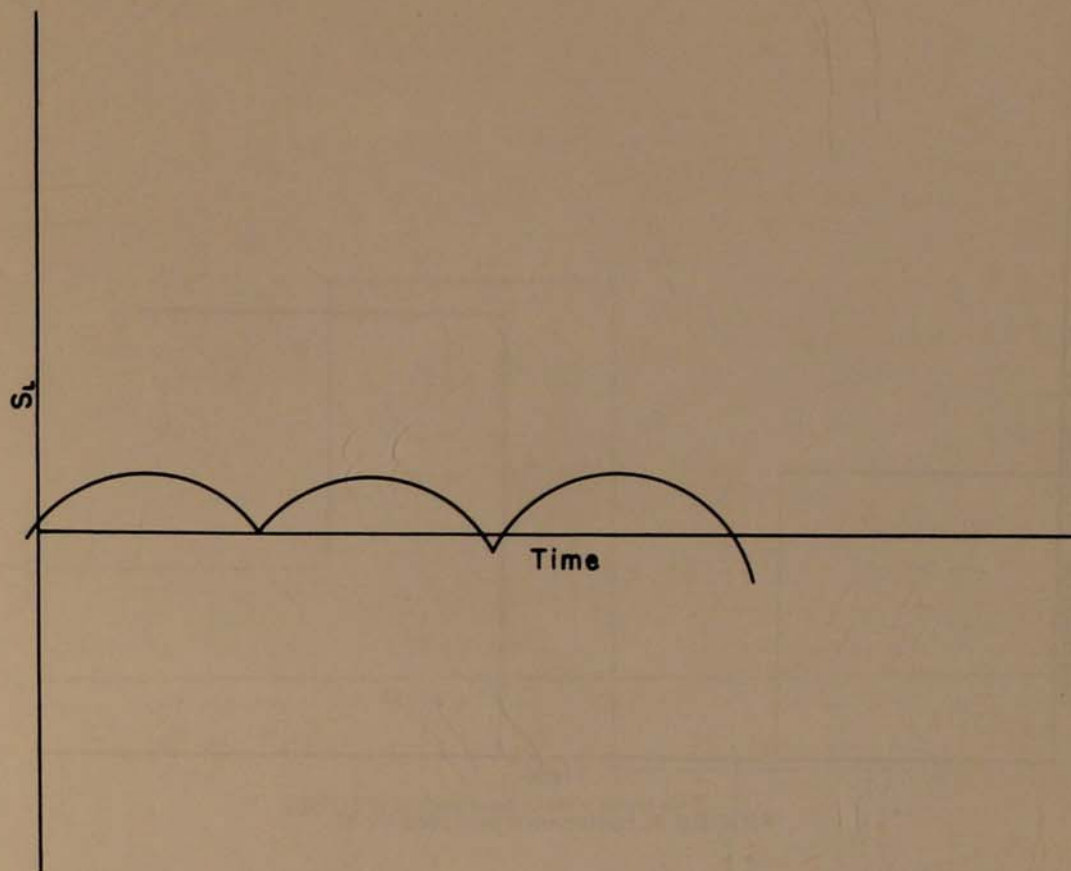


FIGURE 6. State of L.

nique practised in recent years.) Finally, Figures 7, 8 and 9 present a graphical description of Sustenance Provided, N_L , and s_L during a strike. These graphs show that a strike has a very significant effect upon s_L particularly if the sustenance provided is large. Therefore, over a period of years, as the provided sustenance increases (Figure 4), the drop during a strike increases (Figure 7) and thus the effect on s_L of a strike becomes more severe. This may be a reason why the length of strikes has decreased significantly in recent years. (See Berelson and Steiner (1), p. 415.)

Discussions and Conclusions

At this point, there are several comments which should be made and considered. First, the primary objective of this paper is to show that engineering analysis and engineering disciplines can be quite helpful and relevant in the study of social and domestic problems. The above discussion together with the examples, show that indeed social systems can be studied through a mechanical analog. Also, an advantage of this approach is the obtaining of analytical definitions for such commonly used terms as social power, social stress, social state, change, etc.

Second, in many situations, first order rather than second equations occur (see Eqs. (6) and (13)). This means that exponential decay or growth type

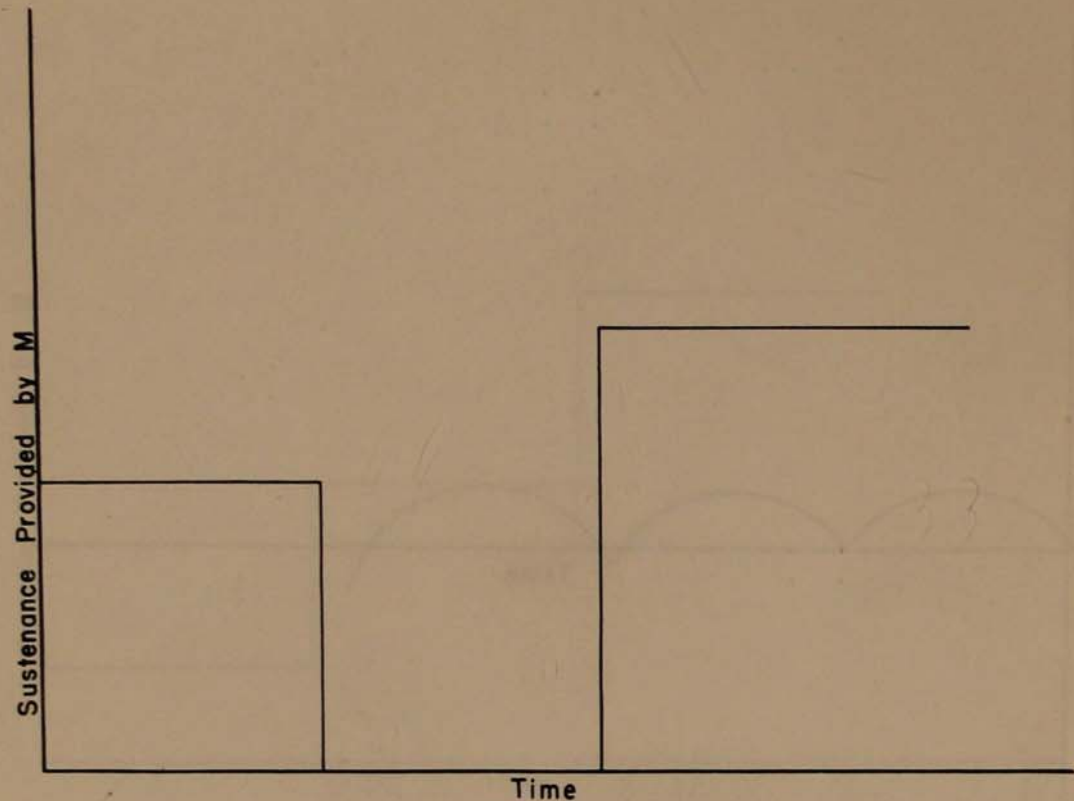


FIGURE 7. Sustenance provided by M.

phenomena will often occur. This agrees with results recorded by Coleman (3) in his treatise.

Third, the examples presented are intended primarily to provide simple illustrations of application of the theory. Clearly, both Civil Disorders and Labor-Management Relations are far more complex than indicated here. In both cases other elements such as government and public opinion should probably be included in a more comprehensive analysis. Also, a more comprehensive analysis should be a vector approach with the simplifying deleted to obtain quantitative results.

Fourth, it is interesting to observe that the graphs used in the examples analogously resemble the familiar v-t and s-t diagrams of elementary mechanics. (See for example, Higdon and Stiles, (7).)

Finally, it should be noted that it may not be necessary to restrict the application of the governing equations to elements containing large numbers of people. That is, the equation might well be used with individuals and then the equations for elements or groups of individuals could be obtained by summation just as equations of motion for rigid bodies (made up of particles) are obtained.

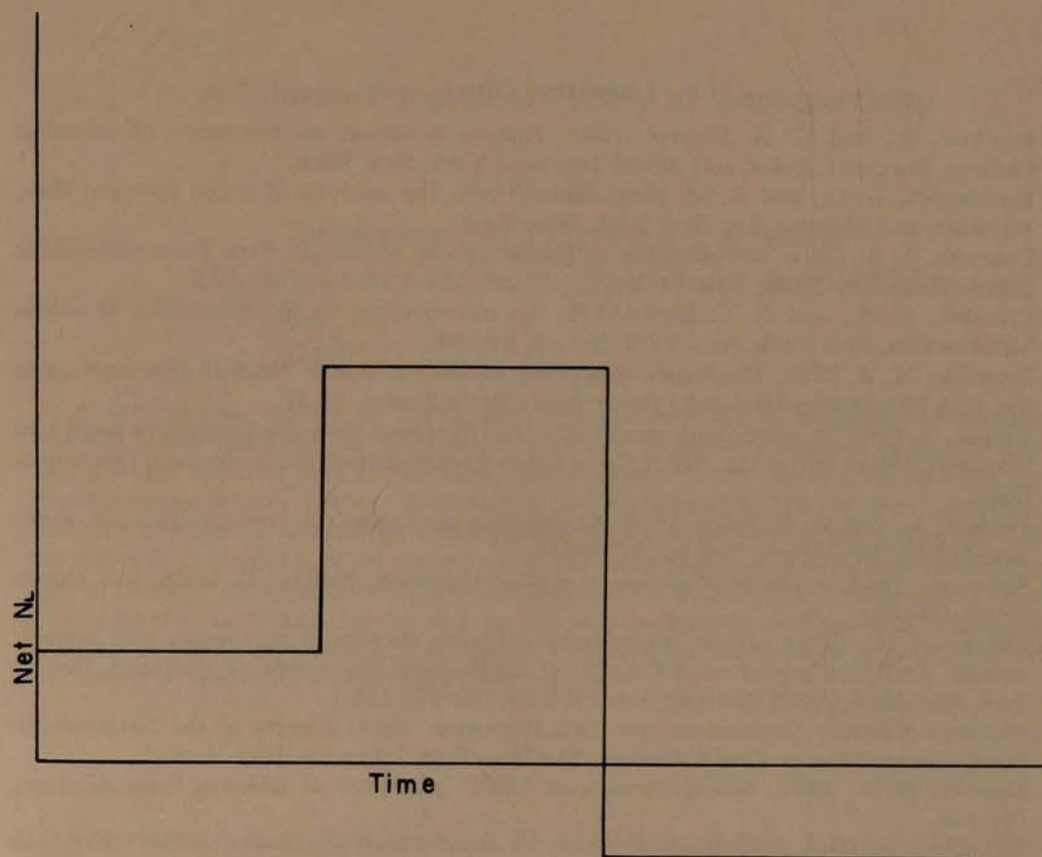


FIGURE 8. Net sustenance need of L.

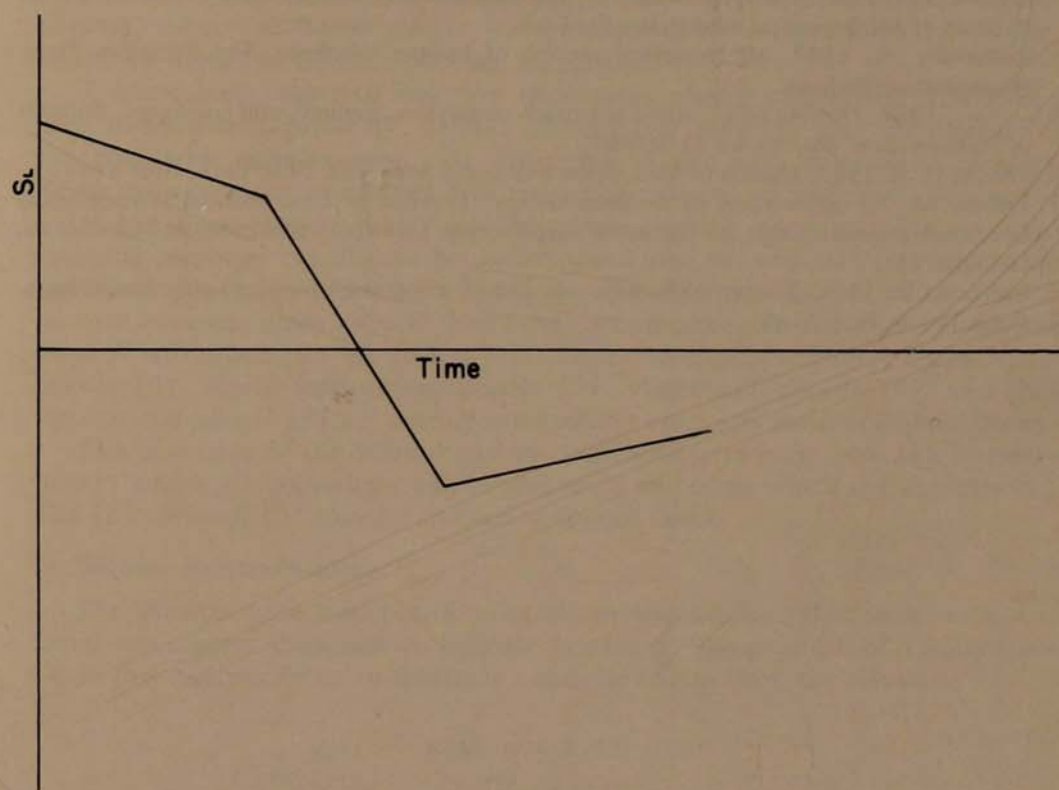


FIGURE 9. State of L.

Literature Cited

1. Berelson, B., and G. A. Steiner. 1964. Human behavior, an inventory of scientific findings. Harcourt, Brace, and World, Inc. New York, New York.
2. Bredemeier, H. C., and R. M. Stephenson. 1964. The analysis of social systems. Holt, Rinehart, and Winston, Inc. New York, New York.
3. Coleman, J. S. 1964. Introduction to mathematical sociology. Free Press of Glencoe (MacMillan). New York, New York.
4. Crandall, S. H., and N. C. Dahl. 1959. An introduction to the mechanics of solids. McGraw-Hill. New York, New York. See pp. 98-104.
5. Emmons, H. W. 1971. The future of applied mechanics. Dev. in Mech.:6 (Proceedings of the 12th Midwestern Mechanics Conference: Notre Dame). 17-31.
6. Glantz, S. 1969. A continuum model of social dynamics with applications to small civil disorders. Presented at the AIAA Great Lakes Regional Student Conference. Cincinnati, Ohio.
7. Higdon, A., and W. B. Stiles. 1957. Engineering mechanics. II. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. See pp. 277-96.
8. Kuhn, A. 1963. A study of society, a unified approach. Richard D. Irwin, Inc. Homewood, Illinois.
9. McGinnies, E. Cross culture investigation of some factors in persuasion and attitude change. Technical report no. 14. Dept. of Psychology. University of Maryland, College Park, Maryland. (ONR Contract Nour 595-21, NR 171-250.)
10. National Advisory Commission on Civil Disorders. 1968. Report of the National Advisory Commission on Civil Disorders. The New York Times Co. New York.
11. Ogburn, W. F. 1931. Social changes in 1930. University of Chicago Press. Chicago, Illinois.
12. Rapoport, A. 1947. Mathematical theory of motivational interaction of two individuals I. *Bulletin of Mathematical Biophysics* 9:17-28.
13. ———. 1947. Mathematical theory of motivational interaction of two individuals II. *Bulletin of Mathematical Biophysics* 9:41-61.
14. Rashevsky, N. 1947. Mathematical theory of human relations. The Principia Press. Bloomington, Indiana.
15. ———. 1969. Outline of a Unified approach to physics, biology, and sociology. *Bulletin of Mathematical Biophysics* 31:159-97.
16. Simon, H. A. 1957. Models of Man. John Wiley and Sons, Inc. New York, New York.
17. Tribus, M. An application in decision theory. Lecture 3: First Annual Distinguished Lectureship Series. Dept. of Chemical Engineering. University of Cincinnati. Cincinnati, Ohio 45221.
18. Volterra, V. 1959. Theory of functionals and of integral and integro-differential equations. Dover, New York.

A Bilinear Functional Theory of Viscoplasticity

A. M. Strauss

*Department of Engineering Analysis
University of Cincinnati, Cincinnati, Ohio 45221*

Abstract

A very general theory of viscoplastic material response is developed. In general, the material strain rates can be decomposed into rate dependent and rate independent parts. The material response in a bilinear function in the rate independent strain rate and the rate dependent strain rate. The rate independent part is obtained by the arc length parameterization of the response which is then transformed back into the time domain. The rate dependent portion is obtained as the difference of the total and rate independent responses. The special cases of additive kernels are considered and the additively separable case is shown to reduce to the viscoplastic theory of Pepe and Strauss. The practical problem of determining the elastic-no-memory-portion of the response is taken up. An example is given on the effect of the elastic properties on viscoplastic behavior.

I. Introduction

This theory is a generalization of the linear theory of viscoplasticity developed by Pepe and Strauss [1]. The viscoplastic theory in [1] is a logical extension of the Pipkin and Rivlin [2] theory of rate independent materials, Strauss' theory of linear plastic (rate independent) materials [3], and the inelasticity theory of Synder, Strauss, and Ho [4].

A viscoplastic material has rate dependent plastic properties. Plasticity is a rate independent property, thus a viscoplastic material may be considered a material with simultaneous rate independent and rate dependent properties. These two material properties give rise to permanent set and creep, respectively.

It has been shown that for continuous loading programs the viscoplastic material response can always be decomposed into the sum of a rate independent part and a rate dependent portion [1]. This decomposition comes about in a natural manner, more natural than other decompositions in common use. Examples of all types can be found, viz. elastic-viscoplastic [5,6], elastic-viscous-plastic [7], elastic-viscous-viscoplastic [7], viscoelastic-plastic [8], and elastic-viscoplastic-plastic [9] are among some of the currently used decompositions.

The objective of the bilinear theory developed here is to provide a framework within which viscoplasticity can be discussed and from which the theories in [1] and [5] through [9] may be derived as special cases.

II. Bilinear Representation

The motion of a viscoplastic continuum will be described with respect to a fixed rectangular Cartesian coordinate system \underline{x} . The position of a generic particle in this continuum at an arbitrary t may be found from the relation

$$\underline{x}(t) = \underline{x}(\underline{X}, t) \quad (2.1)$$

where \underline{x} is a column vector and \underline{X} is the initial position of the particle. The deformation gradient is defined as

$$\underline{F}(t) = \frac{\partial \underline{x}(t)}{\partial \underline{X}(t)} \quad (2.2)$$

as a measure of deformation it is convenient to make use of the Lagrangian strain

$$\underline{E} = \frac{1}{2}(\underline{F}^+ \underline{F} - \underline{I}) \quad (2.3)$$

where $()^+$ denotes the transpose and \underline{I} is the unit matrix.

Let the Cauchy stress tensor be noted by \underline{T}^1 , then the stress at any time t is determined by the entire past motion (history) of the continuum. This type of dependence is of such a general nature so as to preclude any form of useful quantitative theory. Therefore, it is assumed that the material is simple, or the stress at a particle is determined by the history of the neighborhood of the particle. This assumption along with requiring that the stress be independent of arbitrary changes of frame and time scale allows one to write the constitutive relation [10]

$$\underline{T}(t) = \underline{Q}[\underline{E}(\tau)] \Big|_{\tau=0}^{\tau=t} \quad (2.4)$$

where it is assumed that the material was standardized at time $\tau=0$, where τ is the time variable, t the present time, $\underline{T} = \underline{F}^{-1} \underline{T}^1 (\underline{F}^{-1})^+$ is the Kirchoff stress tensor and \underline{Q} denotes a functional defined on the space of histories. If the strain history is continuous (2.4) may also be expressed as

$$\underline{T}(t) = \underline{Q}[\dot{\underline{E}}(\tau)] \Big|_{\tau=0}^{\tau=t} \quad (2.5)$$

where the dot denotes differentiation with respect to time and \underline{Q} is, in general, a functional different from the one in (2.5).

Note that $\underline{Q}[\dot{\underline{E}}]$ is called rate independent if and only if

$$\underline{Q}[\dot{\underline{E}}] = \underline{Q}[\dot{\underline{E}} * S] \equiv \underline{Q}_I \quad (2.6)$$

Where $*$ denotes the operation of composition of functions and S is the arc length parameterization of $\dot{\underline{E}}$,

$$S(\tau) = \int_0^\tau |\dot{\underline{E}}(\xi) \dot{\underline{E}}(\xi)|^{1/2} d\xi \quad (2.7)$$

It has been shown [1] that \underline{Q} may be decomposed into the sum of rate dependent and rate independent parts

$$\underline{Q} = \underline{Q}_D + \underline{Q}_I \quad (2.8)$$

where

$$\underline{Q}_I = \underline{Q} |\dot{\underline{E}}^* \underline{s}|, \quad (2.9)$$

$$\underline{Q}_D = \underline{Q} |\dot{\underline{E}}| - \underline{Q} |\dot{\underline{E}}^* \underline{s}| \quad (2.10)$$

where it is understood that (2.9) will be transformed back into the time domain from the arc length domain by the methods described in [1], for use in (2.10).

Let

$$\underline{Q}_D = \underline{Q} |\dot{\underline{E}}| - \underline{Q} |\dot{\underline{E}}^* \underline{s}| \equiv \underline{Q} |\dot{\underline{E}}_D| \quad (2.11)$$

and

$$\underline{Q}_I = \underline{Q} |\dot{\underline{E}}^* \underline{s}| \equiv \underline{Q} |\dot{\underline{E}}_I| \quad (2.12)$$

Call $\dot{\underline{E}}_D$ the rate dependent strain rate and $\dot{\underline{E}}_I$ the rate independent strain rate. Thus these strain rates may be defined for any viscoplastic process and, in general, the state of stress in a viscoplastic material may be described as a functional of the histories of the rate independent and rate dependent strain rates. This may be written as

$$\underline{T}(t) = \hat{\underline{Q}} |\dot{\underline{E}}_D(\tau); \dot{\underline{E}}_I(\tau)|_{\tau=0}^{\tau=t} \quad (2.13)$$

where $\hat{\underline{Q}}$ is not necessarily the same functional as \underline{Q} , and $\hat{\underline{Q}}$ is a functional of the two histories indicated.

Let us assume that the functional is linear in both its arguments, or it is a bilinear functional. This is the simplest history dependence for a functional of two histories. Bilinearity is defined as follows for constants α and β ,

$$\underline{Q} |\alpha \dot{\underline{E}}_1 + \beta \dot{\underline{E}}_2; \dot{\underline{E}}_3| = \alpha \underline{Q} |\dot{\underline{E}}_1; \dot{\underline{E}}_3| + \beta \underline{Q} |\dot{\underline{E}}_2; \dot{\underline{E}}_3| \quad (2.14)$$

$$\underline{Q} |\dot{\underline{E}}_1; \alpha \dot{\underline{E}}_2 + \beta \dot{\underline{E}}_3| = \alpha \underline{Q} |\dot{\underline{E}}_1; \dot{\underline{E}}_2| + \beta \underline{Q} |\dot{\underline{E}}_1; \dot{\underline{E}}_3| \quad (2.15)$$

On the basis of the bilinear assumption and exact representation may be developed for (2.13) [11], [12]. The bilinear functional representation for (2.13) is

$$\underline{T}(t) = \int_0^t \int_0^t \underline{K}(t-\tau_1, t-\tau_2) \dot{\underline{E}}_D(\tau_1) \dot{\underline{E}}_I(\tau_2) d\tau_1 d\tau_2 \quad (2.16)$$

where the kernel function \underline{K} is a fourth order tensor, and it is assumed the material experiences no aging effects.

III. Separable Kernels

The fourth order kernel function $\underline{K}(\tau_1, \tau_2)$ is defined to be multiplicatively separable if

$$\underline{K}(t-\tau_1, t-\tau_2) = \underline{L}(t-\tau_1) \underline{M}(t-\tau_2) \quad (3.1)$$

where \underline{L} and \underline{M} are fourth order tensor functions of their indicated arguments. Now (3.1) may be written as

$$\underline{T}(t) = \int_0^t \underline{L}(t-\tau) \dot{\underline{E}}_D(\tau) d\tau \int_0^t \underline{M}(t-\tau) \dot{\underline{E}}_I(\tau) d\tau. \quad (3.2)$$

Referring back to (2.13) this type of viscoplastic response is a linear representation of a functional representation of the form

$$\underline{T}(t) = \{ \hat{\underline{Q}}^1 | \dot{\underline{E}}_D(\tau) |_{\tau=0}^{\tau=t} \} \{ \hat{\underline{Q}} | \dot{\underline{E}}_I(\tau) |_{\tau=0}^{\tau=t} \} \quad (3.3)$$

where in general $\hat{\underline{Q}}^1$ and $\hat{\underline{Q}}^2$ will be nonlinear functionals. In the nonlinear case (3.2) will be the first term in the Volterra series expansion of (3.3) [13] [14]. For linear functionals the results of [1] may be applied. Let \underline{N} be the fourth order kernel associated with the linear functional representation of (2.5). Now (3.2) may be expressed in terms of the strain experienced by the materials, $\dot{\underline{E}}(\tau)$,

$$\underline{T}(t) = \int_0^t \underline{N}(t-\tau) \underline{M}(\int_{\tau}^t |\dot{\underline{E}}(\xi) \dot{\underline{E}}(\xi)|^{1/2} d\xi) \dot{\underline{E}}(\tau) d\tau \int_0^t \underline{M}(\int_{\tau}^t |\dot{\underline{E}}(\xi) \dot{\underline{E}}(\xi)|^{1/2} d\xi) \dot{\underline{E}}(\tau) d\tau \quad (3.4)$$

If the process under consideration can be described by an additively separable kernel where

$$\underline{K}(t-\tau_1, t-\tau_2) = \underline{L}(t-\tau_1) + \underline{M}(t-\tau_2) \quad (3.5)$$

Then one may write in the linear case

$$\underline{T}(t) = \int_0^t \underline{L}(t-\tau) \dot{\underline{E}}_D(\tau) d\tau + \int_0^t \underline{M}(t-\tau) \dot{\underline{E}}_I(\tau) d\tau \quad (3.6)$$

which is precisely the result derived in [1]. For a rate dependent material $\dot{\underline{E}}_I=0$ and one obtains the analog to the theory of linear viscoelasticity [15]. However, the elastic response being rate independent is not included in the rate dependent term, and this term represents pure viscous behavior. That is when a load is applied to a material described by (3.6) the rate dependent term will not describe the instantaneous recovery observed upon the removal of the load. Thus elastic type response is described by the rate independent term. Linear viscoelastic models [15], however, describe the instantaneous elastic response.

The rate independent term thus describes instantaneous response as well as the permanent deformation (set) remaining in the material upon unloading. This

term is a generalization of classical rate independent plasticity theory. Almost all of the classical theories may be obtained a suitable choice of kernel function \tilde{M} .

Finally, it should be noted that for (3.6) to be valid the functional \hat{Q} must be continuous. Fewer assumptions need to be made to obtain (3.4) and even weaker assumptions for (2.16). The restrictions which must be placed on \hat{Q} to use (2.16), (3.4), or (3.6) may be obtained from [11].

IV. Elastic Deformation

The elastic portion of the response is defined as the part of the response that is independent of the deformation history. It is essential that the elastic response be determined if the predictions of this viscoplastic theory is to be compared to other theories such as those in [5]-[9].

By definition the elastic response is history independent. It must be a function of the deformation at the present time. The elastic response must also be rate independent, therefore its contribution to the present state of stress must be wholly derived from (2.12) as opposed to (2.11). The elastic response is thus an ordinary function of the strain rate $\dot{\tilde{E}}(S)$

$$\tilde{T}_e(\hat{S}) = \tilde{Q}[\dot{\tilde{E}}(\hat{S})] \quad (4.1)$$

where \tilde{T}_e is the elastic state of stress (response), \hat{S} is the present value of the arc length parameter, $s=\hat{S}$ when $\tau=t$, and \tilde{Q} is an ordinary function of its argument. The entire rate independent relation (4.1) may be easily transformed into the time domain by the methods of [1]. Let us assume that this transformation has been made. The function \tilde{Q} can always be approximated by a polynomial [16] and we may write

$$\tilde{T}_e(t) = \sum_{i=1}^{\infty} q_i \dot{\tilde{E}}^i(t) \quad (4.2)$$

where q_i are polynomial coefficients and $\dot{\tilde{E}}_i(t)$ is still strain rate independent even though it is now a function of time.

The form of the elastic polynomial (response) has very pronounced effects upon the form of the plastic (rate independent) response. To illustrate this point let the elastic (memoryless) response be given as an odd function of the strain

$$\tilde{T}_e(t) = q_1 \dot{\tilde{E}}(t) + q_3 \dot{\tilde{E}}^3(t). \quad (4.3)$$

Consider a pure history dependent response where the entire state of stress depends on the past history and there is no elastic portion of the response. Thus after removal of a given load the viscoplastic materials is observed to experience a time dependent recovery and a permanent set, but no instantaneous recovery. The bilinear functional \tilde{Q}_n will yield this behavior when applied to its arguments $\dot{\tilde{E}}_D(\tau)$ and $\dot{\tilde{E}}_I(\tau)$,

$$\tilde{T}(t) = \tilde{Q}_n \left| \dot{\tilde{E}}_D(\tau); \dot{\tilde{E}}_I(\tau) \right|_{\tau=0}^{\tau=t} \quad (4.4)$$

Now let us observe the effect on the state of stress of allowing the material to exhibit an elastic response of the form (4.3). The most general method of combining these responses is by means of the cascade operation [13], [14]. The cascade of two functionals is the operation of taking a functional of a functional. The algebra of the cascade operation is described in detail in [14] and [17] and an indication of its application in mechanics is given in [18]. The cascade operation will be denoted by the symbol $*$. There are six different ways in which the rate independent, rate dependent, and elastic responses may be combined, and the cascade operation is not in general commutative. Here the rate independent functional will be cascaded with the elastic function and the results of this operation will be cascaded with the rate dependent functional. The rate dependent functional is first linear functional on the right hand side of (3.4) and it will be denoted by \underline{A} ,

$$\underline{A} = \int_0^t \{N(t-\tau) - M(\int_\tau^t |\dot{\underline{E}}(\xi) \dot{\underline{E}}(\xi)|^{1/2} d\xi)\} \dot{\underline{E}}(\tau) d\tau \quad (4.5)$$

and the second linear functional in (3.4), the rate independent one will be denoted by \underline{B}

$$\underline{B} = \int_0^t M(\int_\tau^t |\dot{\underline{E}}(\xi) \dot{\underline{E}}(\xi)|^{1/2} d\xi) \dot{\underline{E}}(\tau) d\tau. \quad (4.6)$$

The elastic memoryless function is given by (4.3). Cascading the responses described above yields

$$\underline{T}(t) = \underline{B} * [q_1 \dot{\underline{E}}(t) + q_3 \dot{\underline{E}}^3(t)] * \underline{A} \quad (4.7)$$

The cascade operation is associative with respect to addition, therefore

$$\{\underline{B} * q_1 \dot{\underline{E}}(t) * \underline{A}\} + \{\underline{B} * q_3 \dot{\underline{E}}^3(t) * \underline{A}\} \quad (4.8)$$

It is well known [14], [17] that the cascade of an n-th order function with a linear functional can be expressed as

$$\begin{aligned} q_n \dot{\underline{E}}^n(t) * \int_0^t K(t-\tau) \dot{\underline{E}}(\tau) d\tau = \\ = q_n \int_0^t \int_0^t \dots \int_0^t K(t-\tau_1, t-\tau_2, \dots, t-\tau_n) \dot{\underline{E}}(\tau_1) \dot{\underline{E}}(\tau_2) \dots \dot{\underline{E}}(\tau_n) \\ d\tau_1 d\tau_2 \dots d\tau_n \end{aligned} \quad (4.9)$$

Thus

$$\underline{T}(t) = \{\underline{B} * q_1 \underline{A}\} + \{\underline{B} * q_3 \underline{A}^3\} \quad (4.10)$$

where \underline{A}^3 is taken to be a triple integral obtained from (4.5) by the law of operation (4.9).

Applying the definition of the cascade operation to equation (4.10) yields,

$$\begin{aligned}
 T(t) = & q_1 \int_0^t M(\int_{\tau_1}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi) [\int_0^t \{ N(t-\tau_2) - M(\int_{\tau_2}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi) \\
 & d\tau_2] d\tau_1 + q_3 \int_0^t M(\int_{\tau_1}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi) [\int_0^t \int_0^t \int_0^t \{ N(t-\tau_2, t-\tau_3, t-\tau_4) \\
 & - M(\int_{\tau_2}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi, \int_{\tau_3}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi, \int_{\tau_4}^t |\dot{\epsilon}(\xi) \dot{\epsilon}(\xi)|^{1/2} d\xi) \\
 & \dot{\epsilon}(\tau_2) \dot{\epsilon}(\tau_3) \dot{\epsilon}(\tau_4) d\tau_2 d\tau_3 d\tau_4] d\tau_1
 \end{aligned}
 \tag{4.11}$$

Thus the state of stress is the sum of two terms. In the first the output of \underline{A} becomes the input to \underline{B} , and in the second the output of \underline{A} becomes the input to \underline{B} . The output of \underline{A} is the first bracketed term in (4.11). This example serves to point out the effects of elastic memoryless material behavior on the response of a viscoplastic material. It also illustrates a general method of combining material characteristics.

Literature Cited

1. Pepe, W. D., and A. M. Strauss. 1971. Theory of Viscoplastic Response. *Archives of Mechanics* 23:3, 405-12.
2. Pipkin, A. C., and R. S. Rivlin. 1965. Mechanics of Rate Independent Materials. *Z. Angew. Math. Phys.* 16:313-26.
3. Strauss, A. M. 1968. *Constitutive Equations for Graphite*, Ph.D. Dissertation, Dept. of Theoretical and Applied Mechanics, West Virginia University.
4. Synder, R. D., A. M. Strauss, and T. L. Ho. 1972. A Non-linear Integral Type Theory of Inelasticity for Transversely Isotropic Materials, in *Developments in Theoretical & Applied Mechanics* Vol. 5.
5. Hohenemser, K., and W. Prager. 1932. Beitrag zur Mechanik des bildsamn Verhaltens von Flusstahl. *Z. Angew. Math. Mech.* 12:216-26.
6. Souissi, M. A., and J. Lemaitre. 1969. Comportment des Metaux a Chaud. Verification d'une Loi Tridimensionnelle de Type Integral. *Comptes Rendus Acad. Sci. Paris Serie A* 269:465-68.
7. Freudenthal, A. M. 1958. The Mathematical Theories of the Inelastic Continuum. *Handbuch der Physik* Band 6, Springer-Verlag, New York.
8. Naghdi, P. M., and S. A. Murch. 1963. On the Mechanical Behavior of Viscoelastic Plastic Solids, Ser. E, *J. Appl. Mech.* 30:321-28.
9. Cristescu, N. 1967. *Dynamic Plasticity*, North-Holland, Amsterdam.
10. Noll, W. 1958. A Mathematical Theory of the Mechanical Behavior of Continuous Media. *Arch. Rational Mech. Anal.* 2:197-226.
11. Gel'fand, I. M., and N.Ya. Vilenkin. 1964. *Generalized Functions*, Vol. 4, Academic Press, New York.
12. Volterra, V. 1959. *Theory of Functionals and of Integral and Integro-Differential Equations*, Dover, New York.
13. Parente, R. B. 1970. Nonlinear Differential Equations and Analytic System Theory. *SIAM J. Appl. Math.* 18:1, 41-66.
14. George, D. A. 1959. *Continuous Nonlinear Systems*, Technical Report 371, Research Laboratory of Electronics, M.I.T., Cambridge, Mass.
15. Coleman, B. D., and W. Noll. 1961. Foundations of Linear Viscoelasticity. *Rev. Modern Phys.* 33.
16. Stone, M. H. 1962. A Generalized Weierstrass Approximation Theorem, in *Studies in Modern Analysis*, ed. R.C. Buck, Math. Assoc. of America Publication.

17. Smith, H. W. 1966. *Approximate Analysis of Randomly Excited Nonlinear Controls*, M.I.T. Press, Cambridge.
18. Strauss, A. M. 1971. Systems Theory Formulation of the Mechanical Behavior of Materials, *Proc. Third World Congress on the Theory of Machines and Mechanisms*, Kupari, Vol. E, paper 25.

Lumbar Dynamic Response of Seat Belted Occupant to Automotive Impact

James C. Goodwin, II

*Department of Industrial Technical Education
Fairmont State College, Fairmont, West Virginia 26554*

Sunder H. Advani

*Department of Theoretical and Applied Mechanics
West Virginia University, Morgantown, West Virginia 26506*

Abstract

The "seat-belt syndrome" type injury encountered in automotive collisions results from mechanical trauma to the spinal lumbar region. This paper presents a multi-degree of freedom dynamic model representing the pelvis, seat belt, lumbar region and upper torso mass. Computed values of dynamic displacement, axial force, shear force and bending moment for a typical automotive impact environment are given. Mechanical considerations pertaining to spinal injury are also discussed.

Introduction

With the advent of the lap type seat belt in the 1950's, the incidence of death went down but a new type of injury evolved, the so-called "seat-belt syndrome" [3]. Trauma caused by the seat belt include both intra-abdominal and spinal injury [3]. Many of the injuries appeared to be caused by loosely or improperly placed seat belts [8, 10]. The purpose of this work is to discuss analytical representations of human spinal response in a typical head-on crash with the effects of a lap seat belt included. Particular attention is focused on the lumbar spine since this region represents the "seat-belt syndrome" injury mode.

Earlier engineering studies of spinal injuries have been associated with the pilot ejection problem. Considerable research has been conducted in this area and solutions for protective seat design have been presented. Analytical work has progressed from one-degree-of-freedom models to a seventeen degree-of-freedom model and several continuum model formulations. Experimental work has involved cadaver and monkey drop tests and measurements of spinal segment constitutive properties.

Human response in simulated seat belt crashes has been experimentally studied using volunteers, cadavers, and anthropometric dummies. Analytically, the problem has been modeled by several different methods. Practically all of these have been concerned with gross body motion rather than the spine in particular. Aquino [1] has investigated the monkey spine with a seat belt constraint. Qualitative agreement between experimental and analytical results was demonstrated.

Model Formulation

The selected model (Figure 1) is similar to that of Orne [7] with the spine separated into discrete elements representing vertebral bodies. The body masses

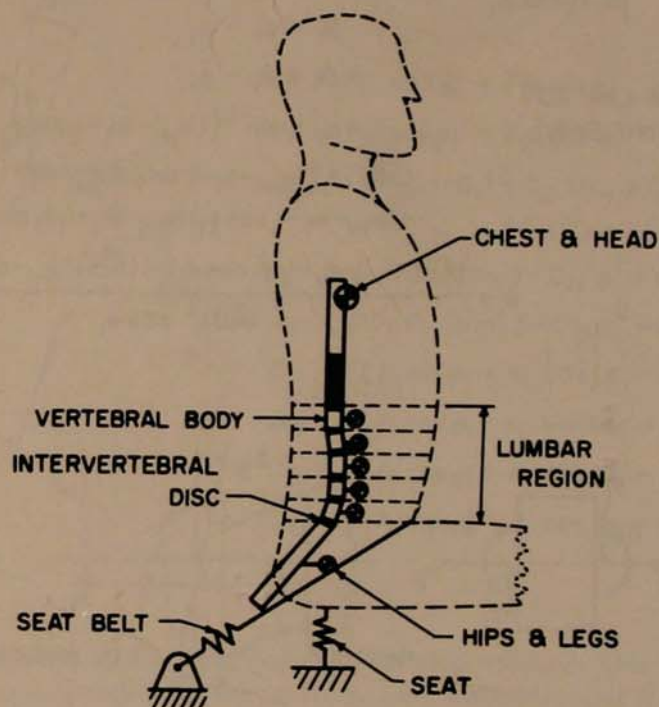
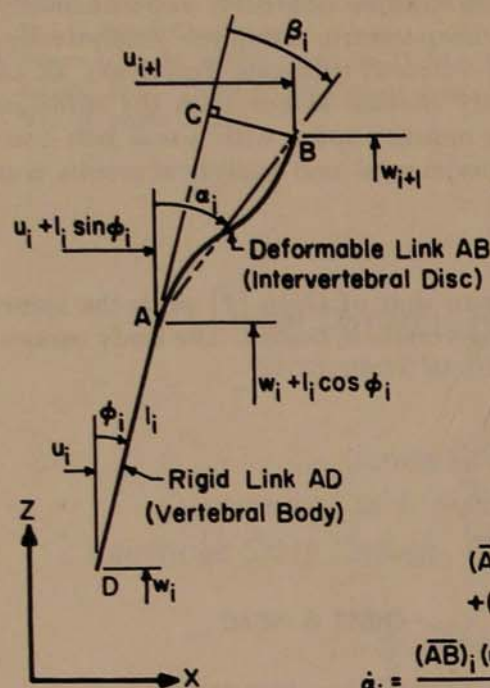


FIGURE 1.

other than the lumbar region are lumped into one large element. A typical element consists of two parts, a rigid link (vertebral body) and a massless deformable link (intervertebral disc). The constitutive properties are incorporated in the deformable link since the vertebral body is much stiffer.

Figure 2 shows a typical element in a deformed position with the coordinates used and Figure 3 shows a typical disc with the lateral, axial and bending deformations indicated. Also shown in Figure 2 are the kinematic equations [7] describing the motion of a typical element. The constitutive relations [7] are shown in Figure 3.

It has been shown [4, 2] that the spine can be represented as a three-parameter viscoelastic material in compression. In tension, however the experimental data is limited. Markolf's [6] and Aquino's [1] results in tension tests represents the disc as a Kelvin-Voigt viscoelastic material. In bending, Markolf [6] observed no increase in stiffness with strain rate which agrees with the



$$\delta_{1i} = (\overline{BC})_i \quad (1)$$

$$\delta_{2i} = (\overline{AC})_i - g_i \quad (2)$$

$$\delta_{3i} = (\phi_i - \phi_{i+1}) - (\phi_i^0 - \phi_{i+1}^0) \quad (3)$$

$$\dot{\delta}_{2i} = (\dot{\overline{AB}})_i \cos \beta_i - \dot{\beta}_i (\overline{BC})_i \quad (4)$$

$$(\overline{BC})_i = (\overline{AB})_i \sin \beta_i \quad (5)$$

$$(\overline{AC})_i = (\overline{AB})_i \cos \beta_i \quad (6)$$

$$(\overline{AB})_i = \left\{ [u_{i+1} - (u_i + l_i \sin \phi_i)]^2 + [w_{i+1} - (w_i + l_i \cos \phi_i)]^2 \right\}^{1/2} \quad (7)$$

$$\beta_i = \alpha_i - \phi_i \quad (8)$$

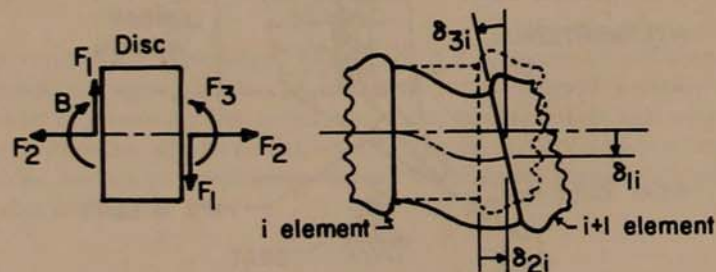
$$\dot{\beta}_i = \dot{\alpha}_i - \dot{\phi}_i \quad (9)$$

$$\alpha_i = \sin^{-1} \left\{ [u_{i+1} - (u_i + l_i \sin \phi_i)] / (\overline{AB})_i \right\} \quad (10)$$

$$(\dot{\overline{AB}})_i = [(u_{i+1} - u_i - l_i \sin \phi_i)(\dot{u}_{i+1} - \dot{u}_i - l_i \dot{\phi}_i \cos \phi_i) + (w_{i+1} - w_i - l_i \cos \phi_i)(\dot{w}_{i+1} - \dot{w}_i + l_i \dot{\phi}_i \sin \phi_i)] / (\overline{AB})_i \quad (11)$$

$$\dot{\alpha}_i = \frac{(\overline{AB})_i (\dot{u}_{i+1} - \dot{u}_i - l_i \dot{\phi}_i \cos \phi_i) - (\dot{\overline{AB}})_i (u_{i+1} - u_i - l_i \sin \phi_i)}{(\overline{AB})_i^2 \cos \alpha_i} \quad (12)$$

FIGURE 2.



$$F_1 = \frac{12EI}{l^3(4\zeta - 3)} \delta_{1i} + \frac{6EI}{l^2(4\zeta - 3)} \delta_{3i} \quad (13)$$

$$F_3 = \frac{6EI}{l^2(4\zeta - 3)} \delta_{1i} + \frac{4\zeta EI}{l(4\zeta - 3)} \delta_{3i} \quad (14)$$

$$\zeta = 1 + \frac{3EI/l^3}{GA/kl} \quad (15)$$

$$F_2 = K \delta_{2i} + C \dot{\delta}_{2i} \quad (16)$$

FIGURE 3.

reasoning of Orne [7] for shear and bending. For shear there is a lack of dynamic properties.

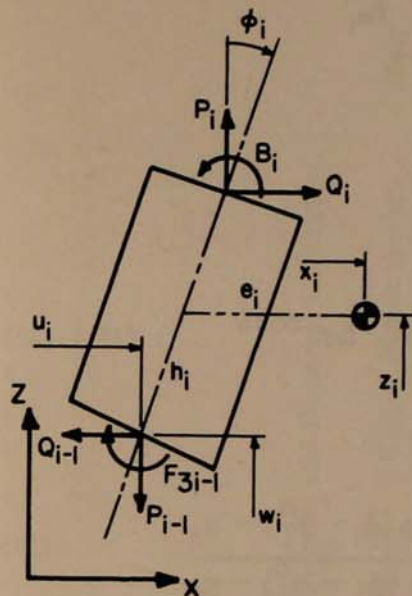
Using the most reasonable data available, the constitutive relations are assumed as elastic in shear and bending and as a viscoelastic Kelvin-Voigt model in

tension/compression. The equation for the axial force (F_2) in Figure 3 differs from that of Orne [7] since tension rather than compression is expected in the seat belt model.

A typical element for the rigid links is shown in Figure 4 with all the forces on it. It can be seen from Figure 3 that

$$B_i = F_{3i} - F_{1i} (AC)_i \quad (17)$$

The equations of motion for the element are also shown in Figure 4 and are the same as Orne's [7] except that the mass center is located horizontally from the



$$Q_i = F_{1i} \cos \phi_i + F_{2i} \sin \phi_i \quad (18)$$

$$P_i = -F_{1i} \sin \phi_i + F_{2i} \cos \phi_i \quad (19)$$

$$J_i \ddot{\phi}_i = (F_{3i-1} - B_i) - C_{2i} Q_{i-1} + C_{3i} Q_i + C_{1i} P_{i-1} - C_{4i} P_i \quad (20)$$

$$\ddot{u}_i = [(Q_i - Q_{i-1})/m_i] - C_{1i} \dot{\phi}_i^2 + C_{2i} \ddot{\phi}_i \quad (21)$$

$$\ddot{w}_i = [(P_i - P_{i-1})/m_i] - C_{2i} \dot{\phi}_i^2 - C_{1i} \ddot{\phi}_i \quad (22)$$

$$C_{1i} = -[h_i \sin \phi_i + e_i \cos (\phi_i - \phi_i^0)] \quad (23)$$

$$C_{2i} = -[h_i \cos \phi_i - e_i \sin (\phi_i - \phi_i^0)] \quad (24)$$

$$C_{3i} = [h_i \cos \phi_i + e_i \sin (\phi_i - \phi_i^0)] \quad (25)$$

$$C_{4i} = [h_i \sin \phi_i - e_i \cos (\phi_i - \phi_i^0)] \quad (26)$$

FIGURE 4.

center of the link instead of perpendicular to its centerline. This position should represent the mass properties taken from Liu, Laborde, and Van Buskirk [5] better.

Solution of Equations

The equations governing the motion of the model include the kinematic equations (1)–(12), the constitutive equations (13)–(16), the force transformations (17)–(19), the equations of motion (20)–(22) and the parameters (23)–(26). There are 26 equations, three of which are second order differential equations requiring six initial conditions, for each element. For the entire model, there are 182 equations and 42 initial conditions.

A boundary condition is imposed by the seat belt. Figure 5 shows the belt represented as a spring connected to a typical element. The force in the belt is given by

$$F_{\text{belt}} = K_{\text{belt}} \left\{ \left[u_i + h_i \sin \phi_i + e_i \cos (\phi_i - \phi_i^0) - u_0 \right]^2 + \left[w_i + h_i \cos \phi_i - e_i \sin (\phi_i - \phi_i^0) - w_0 \right]^2 \right\}^{1/2} \quad (27)$$

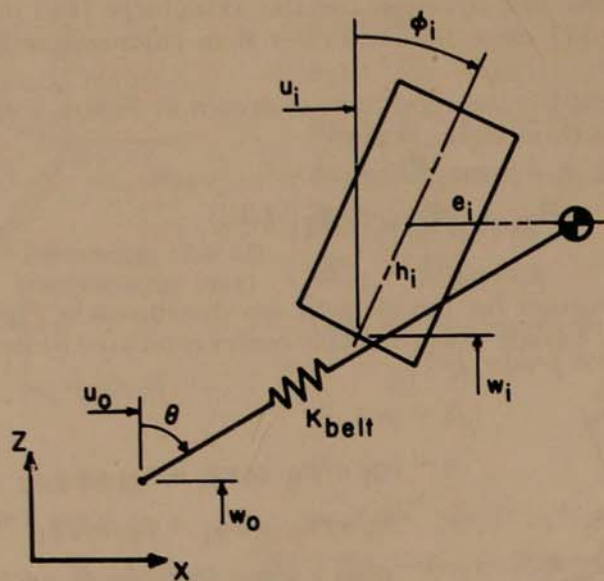


FIGURE 5.

with the components $Q_{belt} = F_{belt} \sin \theta$ and $P_{belt} = F_{belt} \cos \theta$ (28), (29)

where

$$\theta = \frac{u_i + h_i \sin \phi_i + e_i \cos (\phi_i - \phi_i^0) - u_0}{w_i + h_i \cos \phi_i - e_i \sin (\phi_i - \phi_i^0) - w_0} \quad (30)$$

These forces are included in the equations of motion for the element to which the belt is attached. The acceleration of the seat belt anchor is specified as a function of time. It was assumed that in an automotive crash that the vertical acceleration is zero, therefore w_0 is constant.

The seat also presents a boundary condition of the model. It is represented as a spring connected to the pelvis which gives a vertical force under a vertical deflection.

The solution to the equations representing the model was facilitated by the IBM System/360 Continuous System Modeling Program. The RKS method of integration was used which is a fourth-order Runge-Kutta with a variable integration step.

Table 1 shows the geometric and dynamic parameters for the elements of the model. The disc areas, disc heights and initial displacements were taken from Orne [7]. The initial velocities were set equal to zero. The initial angles were calculated using

$$\phi_i^0 = \tan^{-1} [(u_{i+1}^0 - u_i^0) / (w_{i+1}^0 - w_i^0)] \quad (31)$$

Table 1. Geometric and Dynamic Constants

<i>Vertebral Level</i>	<i>Disc Area A (in²)</i>	<i>Disc Height g (in)</i>	<i>Area Moment of Inertia I (in⁴)</i>	<i>Mass Eccentricity e (in)</i>	<i>Initial Displacements</i>		<i>Mass</i>	<i>Rotatory Inertia</i>	<i>Body No.</i>
					<i>Horizontal u (in)</i>	<i>Vertical w (in)</i>	<i>m (lb-sec²/in)</i>	<i>J (lb-sec²-in)</i>	
Pelvis	2.72	0.36	0.30	2.517	-10.00	- 7.00			0
L5	2.66	0.48	0.30	1.5	- 4.80268	- 2.7242	0.1354	0.454	1
L4	2.44	0.42	0.30	1.5	0.0	3.00	0.0132	0.0588	2
L3	2.22	0.41	0.30	1.5	0.40	4.58	0.01265	0.0550	3
L2	1.94	0.38	0.30	1.5	0.53	6.16	0.01210	0.0542	4
L1	1.97	3.80	1.00	1.35	0.47	7.71	0.01155	0.0542	5
				0.553	0.20	9.15	0.01100	0.0626	6
					0.20	14.00	0.11850	5.4661	7

The mass eccentricities, masses and rotatory inertias were taken from Liu, La-borde, and Van Buskirk [5] with some modifications. For the lumped upper body, the mass, mass center and rotatory inertia were calculated from the individual masses and inertias.

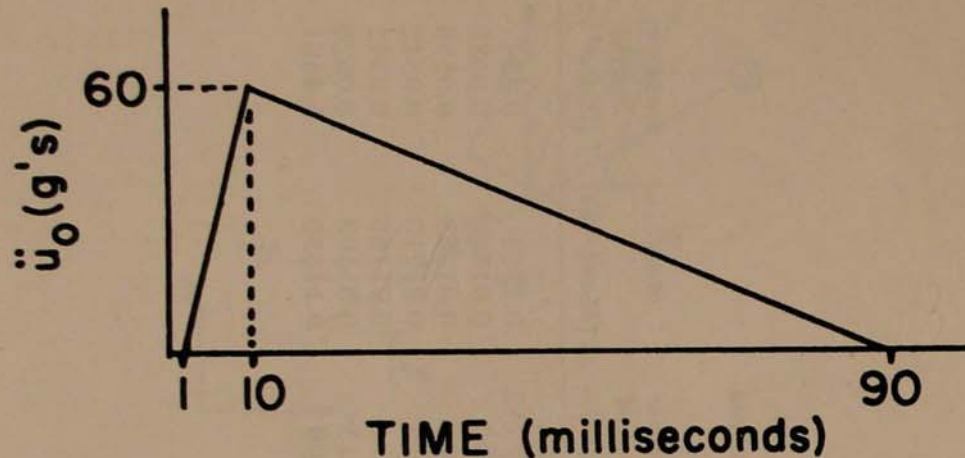


FIGURE 6.

The horizontal acceleration pulse of the seat belt anchor is shown in Figure 6. The shape and peak value were chosen to approximate measured car frame accelerations in crashes by Severy, et al. [9]. This represents a 58.6 MPH crash with a stopping distance of 2.1 feet. The seat belt stiffness K_{belt} was 500 pound per inch and the seat stiffness K_{seat} was 100 pounds per inch.

A shape factor of 1.5 was used for shear. Values for tensional stiffness, tensional damping coefficient, modulus of elasticity and shear modulus of 6000 pounds per inch, 1.0 pound per inch per second, 1000 psi and 600 psi respectively were obtained from Markolf [6].

Results

The simulation was conducted for two crash situations (1) the seat belt connected to the pelvis and (2) the seat belt connected about L4. Figure 7 shows the position of the body at different time intervals after the crash begins for both cases. Figure 8 and 9 show the transverse or shear force F_1 , axial force F_2 and bending moment F_3 on the L5 and L3 vertebrae respectively as a function of time for both cases.

Conclusions and Discussions

Figure 7 shows that the upper part of the body reacts to impact in about the same way for both seat belt positions; but, in the lumbar region the motion is quite different from the different belt positions. With the belt on the pelvis, the body leans forward and rotates about the pelvis; whereas with the belt on L4, the body wraps around the belt and large deflections occur between L4 and L5. Figure 8 indicates that positioning the belt on L4 gives a smaller axial force but a significantly larger shear force and bending moment on the L5 vertebrae. The difference is a trading of a smaller axial force for a larger shear force and bending moment. But, Figure 9 indicates that the forces and moment on the L3 vertebrae are all larger with the belt on L4. This indicates that the proper position for

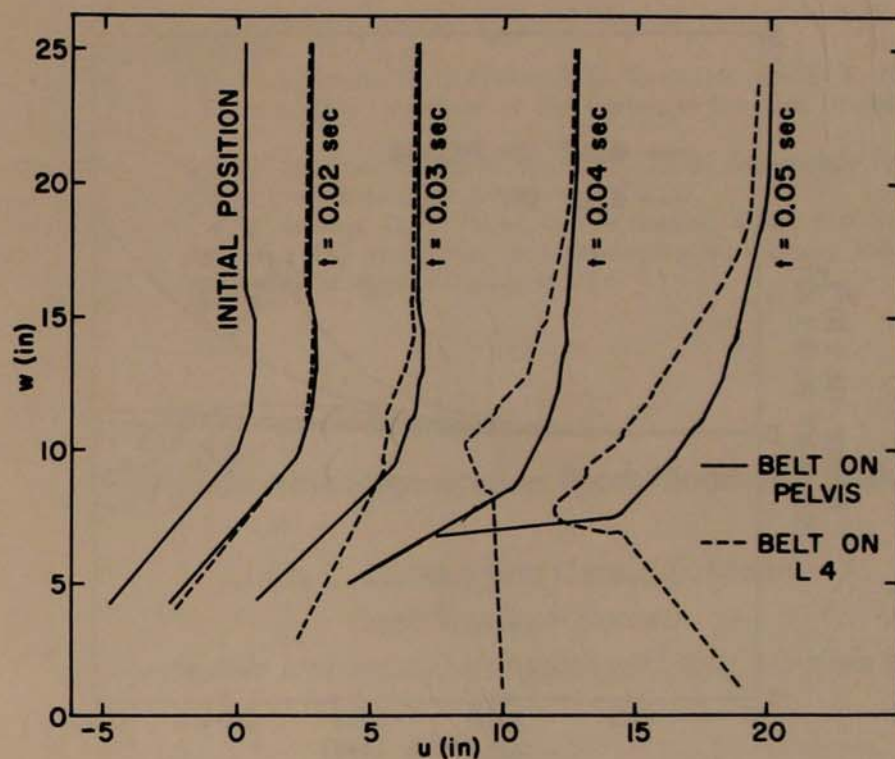


FIGURE 7.

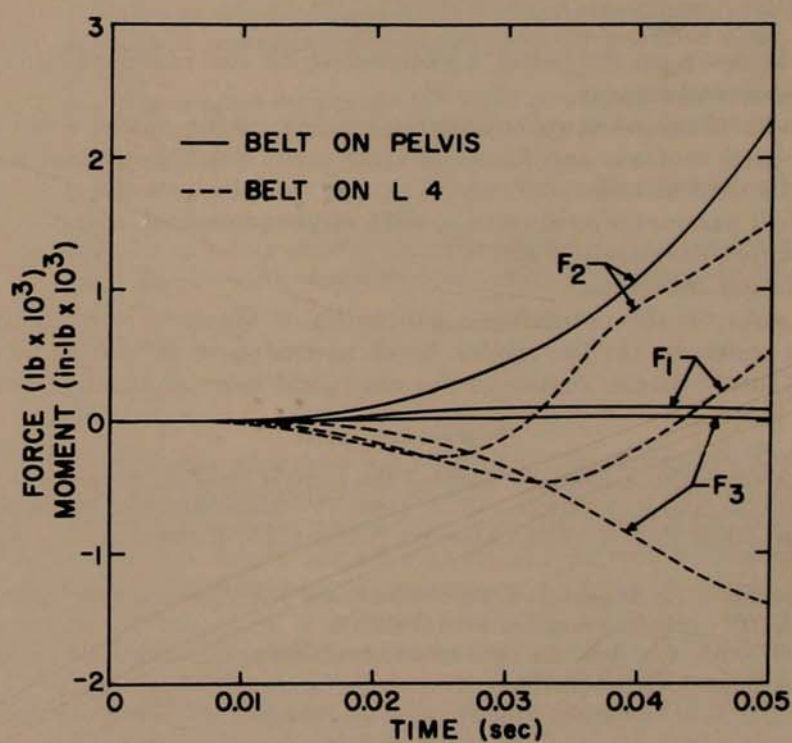


FIGURE 8.

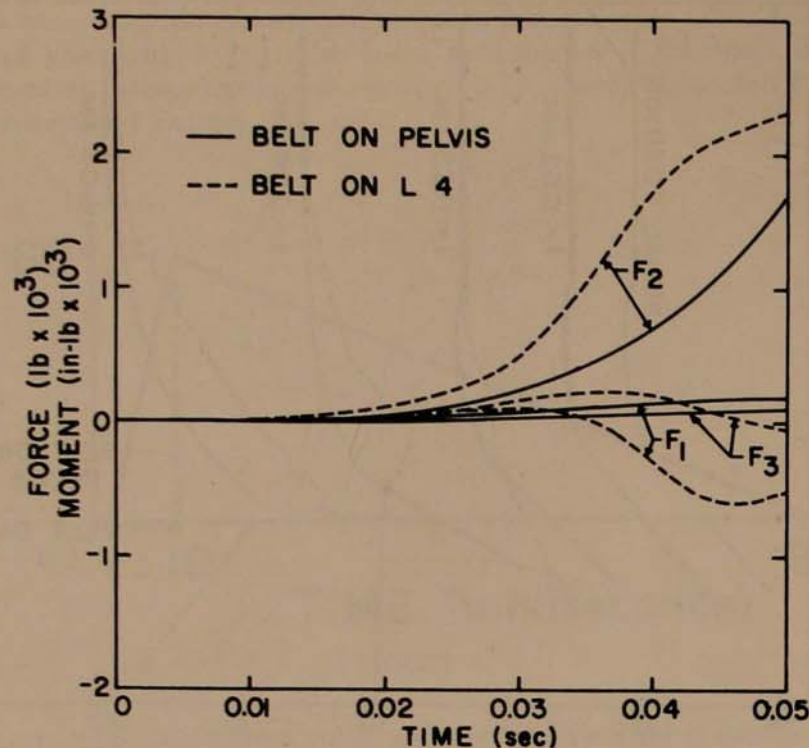


FIGURE 9.

a seat belt is down on the pelvis, a position which also reduces chances of other types of abdominal injuries.

The results obtained show reasonable validity of the model when compared to experimental motions and forces in crash tests. Further studies for which the model can be used include:

1. seat belt parameter optimization with respect to spinal injury
2. adaptation for shoulder belt
3. adaptation for air bag

A lack of data on the constitutive properties of the spine was noted in determining the constants for the model. Work is needed to determine these properties so that future studies similar to this may yield more accurate results.

Literature Cited

1. Aquino, C. F. 1970. A Dynamic Model of the Lumbar Spine. *J. Biomechanics* 3:473-86.
2. Crocker, J. F., and L. S. Higgins. 1966. Phase IV—Investigation of Strength of Isolated Vertebrae. Final Report, NASA Contract NASw-1313, Technology Inc., San Antonio, Texas.
3. Friedman, M. M., L. Becker, J. P. Reichmister, and J. S. Neviaser. 1969. Seat Belt Spinal Fractures. *The American Surgeon* 35:617-18.
4. Hirsch, C. 1965. The Reaction of Intervertebral Disc to Compression Forces. *J. of Bone and Joint Surgery* 37-A:1188-96.
5. Liu, Y. K., J. M. Laborde, and W. C. Van Buskirk. 1971. Inertial Properties of a Segmented Cadaver Trunk: Their Implication in Acceleration Injuries. *Aerospace Medicine* 42:650-57.
6. Markolf, K. L. 1970. Stiffness and Damping Characteristics of the Thoracolumbar Spine. Proceeding of Workshop on Bioengineering Approaches to Problems of the Spine.

7. Orne, D. 1969. A Mathematical Model of Spinal Response to Impact. Ph.D. Dissertation, University of Michigan.
8. Schneider, R. C., W. S. Smith, W. C. Grabb, J. G. Turcotte, and D. F. Huelke. 1968. Lap Seat Belt Injuries; The Treatment of the Fortunate Survivor. *Michigan Medicine* 67:171-86.
9. Severy, D. M., J. H. Mathewson and A. W. Siegel. 1959. Automobile Head-On Collisions—Series II. *SAE Transactions* 67:238-64.
10. Snyder, R. G., J. W. Young, C. C. Snow, and P. Hanson. 1967. Seat Belt Injuries in Impact. Proceeding of The Prevention of Highway Injury. Highway Safety Research Institute, The University of Michigan. April 19-21.

Sulfur Dioxide Regeneration From Modified Flyash*

Linda Z. Condry and Gerald E. Moore

Coal Research Bureau

West Virginia University, Morgantown, West Virginia 26506

Abstract

Sulfur dioxide regeneration properties of modified coal flyash were studied by heating samples of flyash to specific conditions under a neutral atmosphere. Tests have shown that:

- a. When heated in a neutral atmosphere, alkaline-earth modified flyash will evolve sulfur dioxide gas;
- b. This evolution of sulfur dioxide gas will occur at temperatures as low as 1300°F;
- c. This evolution of sulfur dioxide gas will occur in a short period of time, usually within 15 minutes of heating;
- d. Except for the possible presence of an inert carrier gas, the evolved sulfur dioxide gas can be collected in a pure form; and
- e. The evolution of sulfur dioxide gas enhances the natural cementitious properties of the heated alkaline-earth modified coal flyash by increasing the free-lime content of some ashes.

Introduction

This paper presents a method for producing valuable sulfur dioxide gas from a commonly dumped waste material—alkaline-earth modified coal flyash. Modified ash is the solid by-product produced from the combustion of coal from coal-fired boiler systems which use alkaline-earth injection or mixing techniques to fix polluting gaseous sulfur oxides into a solid disposable form. In this process dolomite and/or limestone is injected into the coal boiler during combustion or is mixed with the coal prior to combustion. The alkaline-earth additive absorbs polluting sulfur gases released during the oxidation of the sulfur bearing constituents of coal and fixes them into solid compounds. The sulfur compounds

*A patent application, based on work presented in this paper, has been applied for by the Department of the Interior.

plus the coal ash (modified flyash) are then collected by one of two different methods—wet-collection in which the waste material and the combustion off-gases are passed through a wet-scrubber and are collected in slurry form, and dry-collection in which the waste material is collected in a solid or powdered form by means of a mechanical or electrostatic precipitator.

Large tonnages of modified ash are produced from generating stations which use alkaline-earth modifying systems for abatement of sulfur dioxide pollution.

At present less than five percent of the modified flyash produced is being utilized; the rest is trucked to land fills and dumps. Due to the high sulfur content (10-20% SO_3) and the fine particle size (over 70% is -325 mesh) of modified coal flyash, dumping this material poses serious water pollution and waste disposal problems. This paper describes a method which would utilize large quantities of this modified ash material and at the same time would generate quantities of sulfur dioxide gas in concentrations suitable for use by industry.

Experimental Method

A pre-heated Burrel tube furnace was continuously flushed with helium, the carrier gas, to effect a neutral atmosphere. Once a specific temperature was obtained, weighed samples of alkaline-earth coal flyash were placed in the center of the heated furnace and were allowed to be heated at furnace temperature for 15-30 minutes. Due to small sample size, temperature equilibration was assumed to occur in less than one minute. Effluent gases from the heating process were continuously monitored for the presence of sulfur dioxide by an infrared spectrometer and sulfur dioxide levels were measured at various time intervals by titration methods. Free-lime determinations were made on ashes which had been heated for thirty minute periods. For a schematic of the experimental set-up, see Figure 1.

Other experimental parameters were:

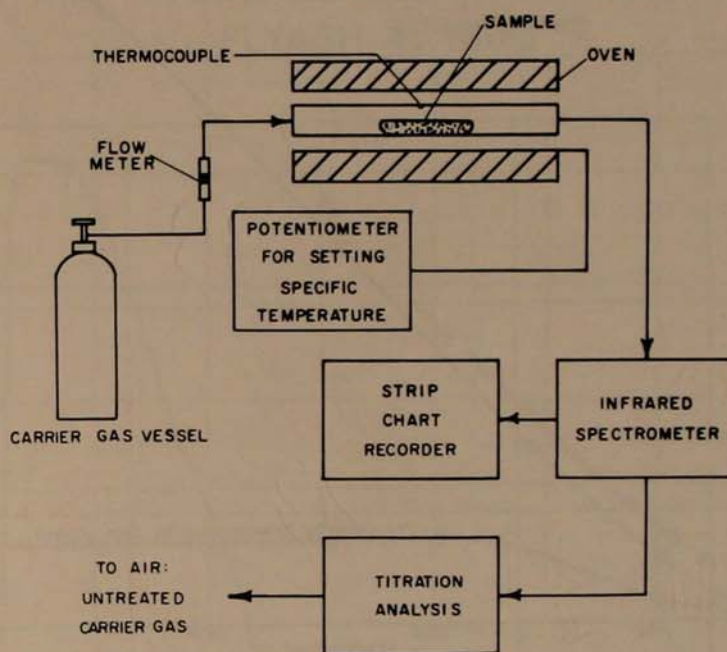
Diameter of reactor tube	2.8 cm
Sample weight	2.0 grams
Temperature Range	1200-2100°F
Equilibration Time	>1 minute
Approximate Gas Velocity over Sample	33.5 cm/min
Infrared Frequency Band for SO_2 Determinations	1340 cm^{-1}

Two different alkaline-earth modified coal flyashes were tested in this manner. One was a sample of wet-collected limestone modified coal flyash received from the Kansas Power and Light Company, Lawrence, Kansas; the other sample tested was a dry-collected dolomite modified coal flyash received from the Chevrolet Motor Division Plant, St. Louis, Missouri. Both limestone modified wet-collected and dolomite modified dry-collected coal flyashes were tested because both the modifying stone and the mode of collection affect the composition of the ash.

The free-lime determination performed on each ash before and after heating measured the amounts of unreacted calcium oxide and magnesium oxide present in the ash. This was considered to be an important determination since the free-lime present in the ash is capable of mixing with the inherent pozzolanic portions of the flyash to form a natural cementitious material. The greater the amount of free lime present in a modified ash, the more pronounced are the

FIGURE 1

SCHEMATIC OF EXPERIMENTAL DESIGN

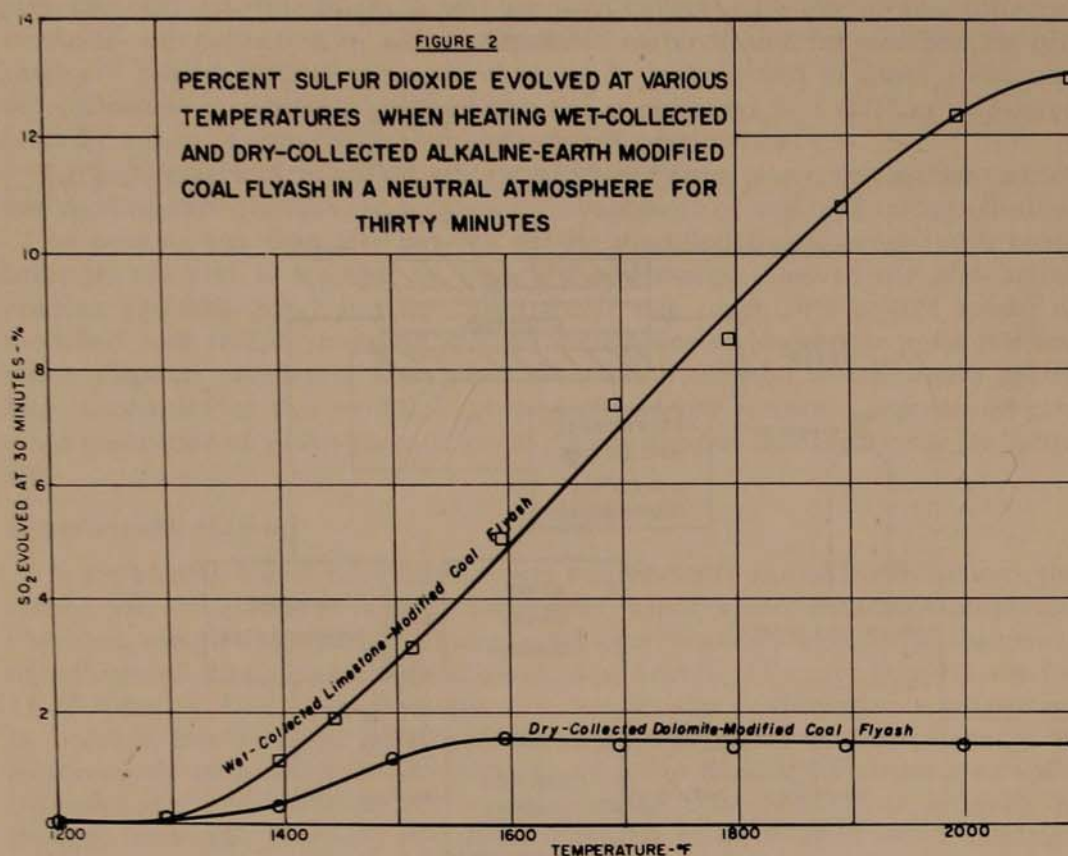


potential cementitious properties of the ash. Therefore, two gram samples of each ash were tested both before and after heating to determine what effect, if any, heating had upon the free-lime values. A modification of the Moorehead and Taylor method⁴ for calcium oxide determination was used for continuity and all heated samples were tested after a 30 minute heating period.

Experimental Results and Discussion

Results of this investigation show that upon heating alkaline-earth modified coal flyash in a neutral atmosphere sulfur dioxide is evolved and that this evolution occurs at temperatures as low as 1300°F. Figure 2 depicts the relationship between the temperature of the heated ash and the total amount of sulfur dioxide evolved after an arbitrary heating time of thirty minutes. As is graphically shown, both the dry- and wet-collected ashes began to evolve sulfur dioxide at approximately 1300°F. This temperature is significantly lower than the decomposition temperature range of calcium sulfate which occurs around 2192-2552°F.¹ It also may be noted that for increasing temperatures, the wet-collected modified coal flyash showed a significant increase in the amount of sulfur dioxide evolved as compared to the dry-collected ash. This difference appears to be caused by the difference in composition.

Also, in a neutral atmosphere, the length of heating time needed to evolve the sulfur dioxide may be considered short. As an example, Figures 3 and 4 depict the heating times necessary for sulfur dioxide evolution when two gram samples of both the wet- and dry-collected ashes are heated to 1800°F. These figures show that for wet-collected limestone modified coal flyash almost all the sulfur



dioxide that is evolved at 1800°F (8.6%) is given off in 15 minutes and for dry-collected dolomite modified coal flyash all the sulfur dioxide that is evolved at 1800°F (1.4%) is given off within five minutes. These time intervals decrease with increasing temperatures.

Upon heating modified coal flyash, two impurities were noted—carbon dioxide (CO_2) and water vapor. Both impurities can be completely evolved, however, at much lower temperatures (approximately 900°F) than those involved in sulfur dioxide evolution. Therefore, these impurities may be extracted before the actual evolution of sulfur dioxide occurs and except for the possible presence of an inert carrier gas, the sulfur dioxide that is regenerated from modified coal flyash may be considered a pure gas.

Results of the free-lime determinations are shown in Figure 5. Although heating reduced the free-lime content of dry-collected dolomite modified coal flyash, wet-collected limestone modified coal flyash displayed a two-fold increase in free-lime. This two-fold increase in free-lime content upon heating significantly increases the potential cementitious activity of this ash.

Acknowledgments

The authors of this paper wish to thank the Control Systems Division, Office of Air Programs, of the Department of Health, Education, and Welfare for their help in supplying modified coal flyash samples and in funding this project.

FIGURE 3

RELATIVE TIME OF SULFUR DIOXIDE EVOLUTION
FOR WET-COLLECTED LIMESTONE-MODIFIED COAL
FLYASH AT 1800° F.

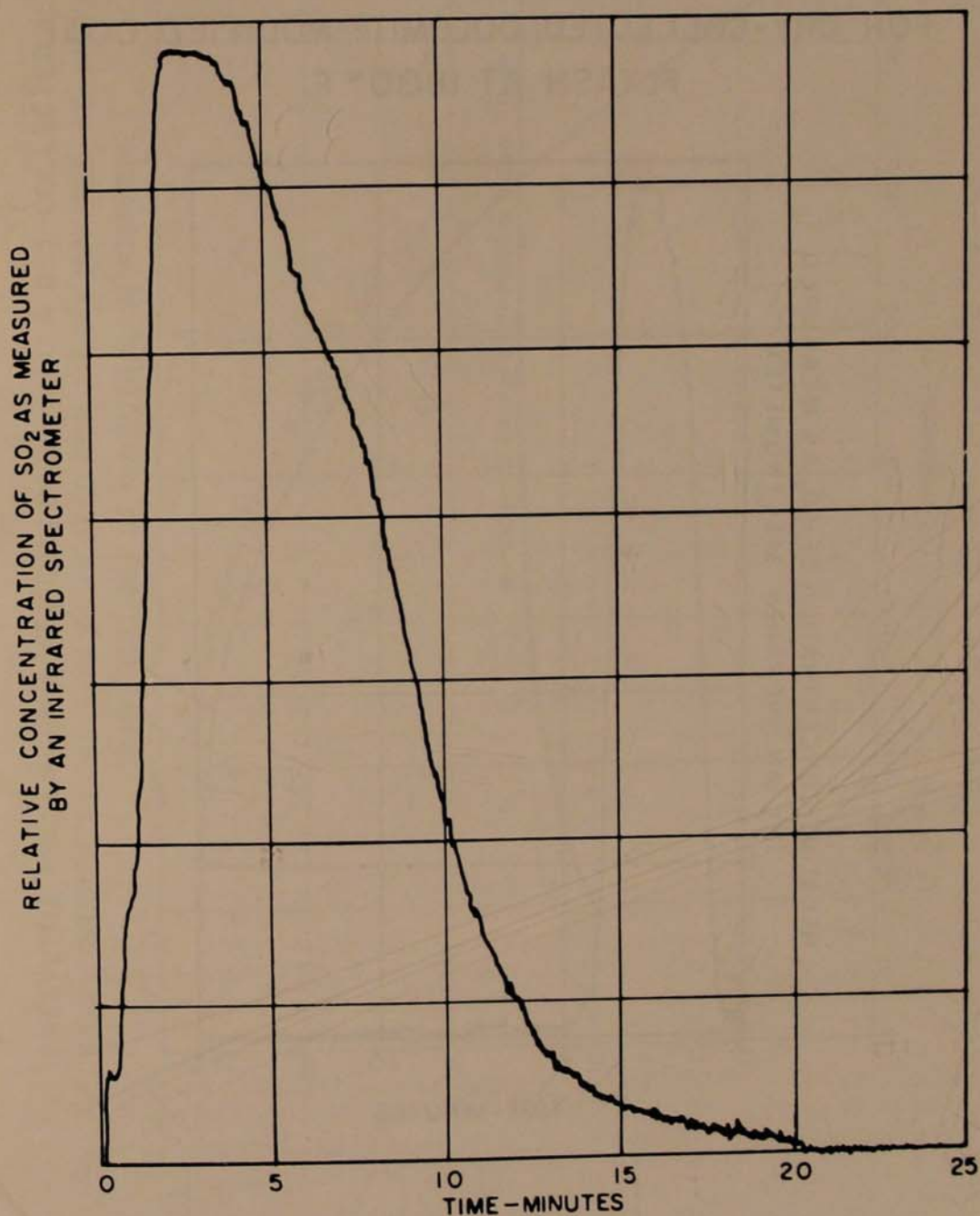


FIGURE 4

RELATIVE TIME OF SULFUR DIOXIDE EVOLUTION
FOR DRY-COLLECTED DOLOMITE-MODIFIED COAL
FLYASH AT 1800° F.

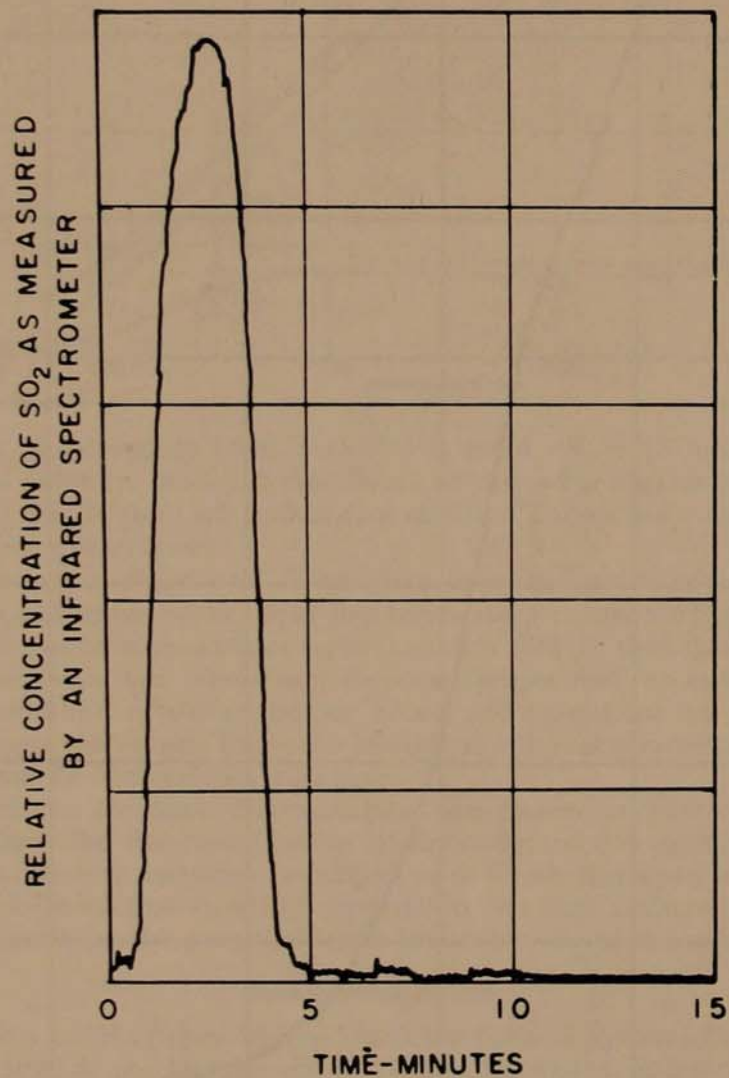
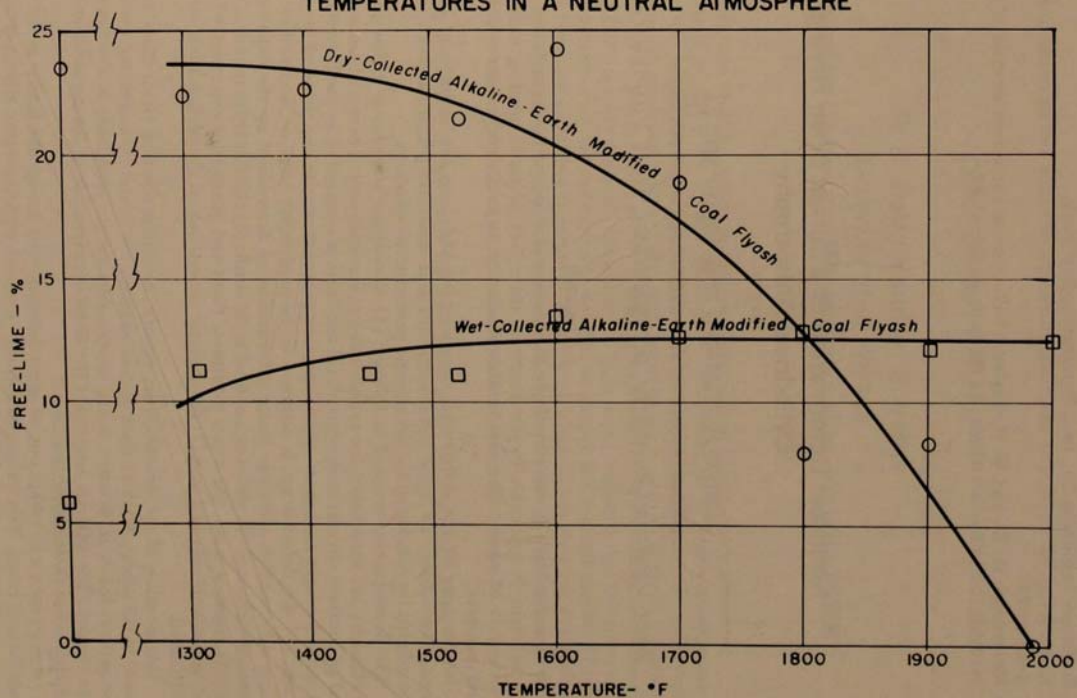


FIGURE 5

FREE-LIME PRESENT IN A WET-COLLECTED AND A DRY-COLLECTED ALKALINE-EARTH MODIFIED COAL FLYASH HEATED FOR THIRTY MINUTES AT VARIOUS TEMPERATURES IN A NEUTRAL ATMOSPHERE



Literature Cited

1. Boynton, Robert S. 1967. Chemistry and technology of lime and limestone. Interscience Publishers, Inc., New York. 5-31 pp.
2. Duecker, Werner W., and James R. West. 1961. The manufacture of sulfuric acid. Robert E. Krieger Publishing Co., Inc., Huntington, New York.
3. Karchmer, J. H. 1970. The analytical chemistry of sulfur and its compounds. *Chemical Analysis* 29.
4. Moorehead, D. R., and W. H. Taylor. 1967. Sucrose extraction method of determining available CaO in hydrated lime. *ASTM Bulletin* 236:45-47.

Nonlinear Deformation of a Curved Beam Having Cylindrical Anisotropy

James R. Stafford and Teng-Fang Li

Department of Mechanical Engineering

West Virginia University, Morgantown, West Virginia 26506

Abstract

A moment loaded, curved anisotropic beam was analyzed by perturbation techniques. The solution is applicable to the study of the effect of static bending moments on the deformation of curved filaments in fiber reinforced materials and anisotropic curved structural members.

Nonlinearity of the differential equations resulted from the inclusion of large rotation terms. The validity of linear approximations and nonlinear perturbation corrections were investigated by comparing the asymptotic perturbation solutions.

The developments proceed as follows: (1) Novozhilov's nonlinear differential equations of elasticity are established for cylindrically anisotropic curved beams of constant curvature and of constant circular cross-section, (2) the beam is assumed to be cantilevered and loaded by an end couple having an axis of rotation perpendicular to the plane of the undeformed beam, (3) the deformation is assumed to be moderately large or intermediate to classical linear deformation and large finite deformation as determined by the rotation of circumferential elements, (4) strain is assumed to be small, (5) the thickness to radius of curvature ratio is assumed small, (6) a two parameter (load and geometric) expansion of the dependent variables is assumed, and (7) the analytic expressions of the perturbation corrections are established.

Linearization of the developed asymptotic, nonlinear solution yields classical linear solutions. In particular, Winkler Bach approximations are found by neglecting certain terms in the general solution. Straight beam approximations are applicable in a defined boundary-layer region. The analysis establishes the order of magnitude of the perturbation parameters which control these approximations.

Anisotropy can create out of plane bending even though the load is in the plane of the undeformed beam. This "material torsion" coupled with curvature effects creates excessive transverse displacements in long-span curved beams.

Large deformations of curved beams analyzed resulted in unsymmetrical geometry of deformation and, therefore, unsymmetrical stress functions. This is contrary to the observations of linear small deformation analysis which yields symmetric stress functions.

Color Centers In CaF_2

R. B. DeVore and W. E. Vehse

Department of Physics

West Virginia University, Morgantown, West Virginia 26506

Abstract

A brief description of color centers in CaF_2 and methods of production is presented.

The coloration of CaF_2 by 2 MeV electrons* was found to be highly temperature dependent. Below 145°K the main optical absorption band is the F band. At 20°K and below, F centers are produced rather easily; then between 20°K and 77°K there is a rapid drop in the rate of coloration followed by a much slower drop to 145°K . Since the F band, produced at 20°K does not thermally anneal at 77°K , it was concluded that the observed temperature dependence of the coloration is not due to simply the thermal motion of the interstitials. A radiation annealing experiment is reported which shows that it is a radiation induced back reaction which is the limiting factor in the formation of F-centers between 77°K and 145°K .

The production, reorientation and identification of M-centers is discussed.

*Irradiations performed at Oak Ridge National Laboratory, Solid State Division.

Psychology and Education Section

Some Social and Economic Value Orientations of Social Science Textbooks in West Virginia Public Schools

J. M. Gaither, R. L. Decker, and J. D. Moore

Department of Psychology

West Virginia University, Morgantown, West Virginia 26506

Abstract

Fifteen social science textbooks used in grades 10, 11 and 12 in several counties were reviewed and rated for their fairness and adequacy in relation to the labor movement, its goals, ideology, and contributions. The purpose of this preliminary study was to determine whether or not conditions were similar to those reported by Scoggins (1966) after his review and study of California's public school texts. It was concluded that, based upon the judgments of the raters involved, West Virginia's public school texts are biased in an anti-labor and anti-liberal direction. It is recommended that further more intensive evaluation be made and that other interests in our society be included in the decision making process in the selection of texts.

Introduction

The purpose of this study is to perform a preliminary evaluation of some of the social studies textbooks being used in the West Virginia public schools system to determine whether or not the textbooks offer an unbiased and adequate presentation of information relating directly or indirectly to the American labor movement.

Nature of the Problem

Union spokesmen have often complained of the treatment the labor movement receives in the secondary schools. For example, they feel that the textbooks do not credit organized labor for its role in the growth of the economy, but do cite instances of union violence. (Doherty 1963.)

Many studies show that both students and teachers do not have a clear understanding of the labor movement in America and have unfavorable attitudes toward unions. The biased approach of many textbooks has done much to promote the misunderstanding and negative attitudes.

Union leaders and labor economists feel that the unfavorable view of students, both high school and college, may pose problems for the growth of unionism in this country. Many investigations indicate that students and teachers, regardless of their family backgrounds express anti-union biases. (Cook, 1969, and Martin, 1968.) The textbooks which they have studied in the critical

years of high school and junior high school could have contributed greatly to this.

The United States is moving from a production economy to that of a service economy. If the unions are to maintain their relative strength, they will have to organize the white-collar and technical workers. (Reese, 1965.)

If high school students continue to be exposed to and highly influenced by a biased and negative approach of both textbooks and teachers, they may enter the work force ill-prepared to meet their responsibilities as an employee.

The overwhelming majority of today's young Americans expect to become employed. The very first year following their graduation from high school finds 90% of the boys who do not attend college in the labor force, and a startling 72% of the girls are joining them. Boys and girls together are becoming somebody's employees . . . What are these young people being taught about what it means to be an employee? (Scoggins, 1966, p. 1.)

Scoggins poses the general question with which this study will be concerned. Are the high school students in West Virginia being given an unbiased and adequate preparation to meet their responsibilities of an employee?

It is the assumption of the authors of this paper that organizational activities associated with one's employment, whether it be unskilled, craft, or professional, constitute an honorable, productive type of involvement which among other things, is virtually essential for the protection of individual practitioners.

Statement of Hypothesis

The hypothesis of this study is that Social Studies textbooks currently being used in the West Virginia school system, grades ten through twelve, present a negative bias of the American labor movement.

This hypothesis is based on the assumptions and conclusions of other studies done on the evaluation of social studies textbooks, primarily that of Scoggins (1966).

If this hypothesis is supported one could conclude that high school students, entering the work force may hold hostile views toward unions. Therefore, they are placed in a situation that they are not prepared to cope with; that is, hostility toward an organization that becomes the guardian of their individual rights.

Review of Literature

An investigation of the literature pertaining to the evaluation of social studies textbooks reveals that although there has been much criticism of the texts, the actual number of systematic studies done concerning evaluation is very small.

Scoggins (1966) has produced an excellent monograph concerning social studies texts used in the 11th and 12th grades of high schools of Los Angeles County in the state of California. His procedures included the reading of textbooks and other educational materials as well as questionnaires and interviews with teachers. He concluded that students were not being taught information which could realistically be applied to their expectations of entering the work force. Review of the citations and quotations for these texts suggests that they are extremely anti-union and anti-organization, (Scoggins, 1966). Other writers and investigators such as, (Alexander, 1969, Doherty, 1963; and Nicholas & Ochoa, 1971)

have concluded that textbooks may be having undesirable or at least significant and unknown effects upon the values, perceptions and views of students. It also seems to be the general conclusion that textbooks should be evaluated not on the basis of their usefulness to the teacher or upon their qualities as books but on the effects that they may have upon the students.

If the quality of education is to be improved considerable attention must be placed on the content of the textbooks. The books will not begin to approach the standards of honest, realistic and readable presentation, unless the students, teachers and especially parents demand that their interest in quality education be given the highest priority. (Moore, 1969.)

Methodology

The fifteen social science textbooks used in grades 10, 11, 12 in the counties of Monongalia, Lewis, Barbour, and Upshur were reviewed. These texts were those concerned with such areas as history, culture, economics, and sociology. These texts were first read by two graduate students in industrial relations and rated according to the scale used by Scoggins on the 35 labor topics which he used for evaluation. Those parts of the texts devoted to the above subjects were then intensively read by an Associate Professor of Psychology with experience in the field of industrial relations and contact with the labor movement. This reader rated each text on a five-point scale ranging from extreme anti-union bias, through mild anti-union bias, neutral (fair and impartial), to mild and extreme pro-union bias, on the twelve topics. These included labor unions in general, collective bargaining, labor legislation, history of labor movement, government regulation of business, our economic system, distribution of wealth, financing of social and public services, protection of employees, individualism vs. group activities, inflation in relation to wages, prices and the cost of living.

Results and Discussion

The results of the evaluation of the texts using the Scoggins rating scale are given in Table 1.

Table 1. Evaluation of 35 Labor Topics as Presented in Social Studies Textbooks for Grade 10 Through 12*

LABOR TOPICS	S	M	DI	DA	EI	EA
1. Strikes and Lockouts	0	3	6	5		1
2. Political Activity of Unions	2	6	4	2		1
3. Injunctions against Unions	5	4	4	1		1
4. Arbitration	5	5	3	1		1
5. Mediation & Conciliation	8	3	2	1		1
6. Open Shop	7	2	2	3		1
7. Closed Shop	5	5	2	3		
8. Union Shop	7	2	2	4		
9. Company Unions	7	3	2	2		1
10. Industrial vs. Craft Unions	2	6	3	3		1
11. Section 7 (a) of the NIRA	6	1	1	1		1
12. Section 7 (a) of the NLRA	2	4	4	1	2	2
13. Fair Labor Standards Act	3	3	5	2		1

14. Taft-Hartley Act			5	1	2	2
15. Landrum-Griffin Act	5	1	4	3		2
16. Management Unfair Practices	2	7	3	3		
17. Labor Unfair Practices	2	8	3	2		
18. Right-to-work Laws	8	5		1		1
19. Strikes by Public Employees	9	4	2			
20. Collective Bargaining		6	4	4		2
21. Automation		4	4	4		3
22. Social Security Act (general treatment)			8	5	1	1
23. Major Benefits under Social Security	1	3	7	2		2
24. Unemployment Insurance	1	3	4	4		3
25. Aid to the Blind	4	5	1	2	1	2
26. Aid for Dependent	2	6	3	1		3
27. Aid for the Disabled	1	8	2	1		3
28. Maternal and Children Services	5	5	1	2		2
29. Public Employment Services	2	8	1	2		2
30. Old-Age Assistance	2	8	1	2		2
31. Medicare	3	5	4	2		1
32. Workmen's Compensation		5	4	1		1
33. State Disability Insurance	2	5	3	3	1	1
34. Individual Income Tax	2	3	3	4		3
35. Corporate Income Tax	4	3	5	1		2

*Symbols used in evaluation: S—silent on subject
M—mentioned, but no description or explanation
DI—described inadequately
DA—described adequately
EI—explained inadequately
EA—explained adequately

Visual inspection of percentages computed in Table 2 indicated the percentage of books in each of the rating categories, followed those of the Scoggins study with insignificant variations.

Table 2. Comparison of Scoggins Study and the West Virginia Study.

	<i>N=33</i> <i>Scoggins</i> <i>Study</i>	<i>N=15</i> <i>West Virginia</i> <i>Study</i>
S	28%	25%
M	26%	29%
DI	18%	21%
DA	19%	16%
EI	2%	1%
EA	7%	8%

The conclusion of the rater evaluating the bias of the books on the twelve items, indicated that none of the books could be regarded wholly or in part as pro-union. Further ratings of these books indicate that, to an individual sympa-

thetic to the labor movement and aware of its contributions, as well as being sensitive to the social value content of written expression all the books could be regarded as being in varying degrees anti-labor. Of the fifteen books in this study only one received ratings of 3, Neutral-Fair and Impartial treatment on any of the 12 items. The book by Smith, A. H. (et al.) *Economics for Our Times*, received ratings of "3" on the subject matter items of Labor Unions in General, Collective Bargaining, and History of Labor Movement. All other books which dealt with the listed subject matter areas were regarded to be essentially anti-labor. The above-mentioned book by Smith has what might be considered an excellent chapter on the labor movement. One of the rare ones incidentally which even includes a separate chapter devoted to it. However, discussions of labor legislation using terms such as "right to work" laws and the protection of the consumer of "crippling" strikes are occasionally used in a manner which would leave a negative perception with the reader.

Rated the most anti-labor of all the books studied was *Social Living*, by Paul H. Landis. On page 264 he states "only in situations where a worker is easily replaced and therefore of little value (to his employer) is a union of workers necessary." It would seem that anything the book could state after such an introduction would have a negative value. One might wonder if such a description fits the role of a physician, whose American Medical Association could certainly be regarded as a union, and his worth to society and his employer, the patient. At another point the text states "Labor has a responsibility in keeping wage demands reasonable and promoting increased worker production." Without mentioning that there may be some controversy about how the wealth of our society is distributed and that labor may not find it desirable to remain at the lower end of the economic scale as an indication of his worth. On page 291 the book suggests that the government has stepped in to guarantee the laborer his daily bread and that society makes provision for the weak, sick, aged, maimed, etc., as though there were no problems in these areas. In this book as in most of the others, items such as unemployment compensation, sickness benefits, and legislation relating to these matters are often treated as something which simply resulted from the spontaneous action of a generous society rather than recognizing the fundamental role of the labor movement in securing them for labor. On page 286 Landis laments the fact that during the depression, honest people had to go on relief with the "unemployables and shiftless." Small wonder that developing citizens and future taxpayers may resist paying taxes and have a grossly distorted picture of the poor. On page 263 he states "The average worker in our country enjoys a standard of living that is unrivaled in the history of the world." This theme is repeated fairly consistently through the various texts. Often seeming to imply that workers should be more appreciative of their life of ease and that they are ungrateful for desiring more. None of the texts were sufficiently up to date or sophisticated economically to recognize the real difficulties faced by larger sections of the American workers. In relation to social services and welfare it is interesting to note that the author tells the students that many doctors resist socialized medicine "for fear it will become political." Some may suspect the physician of other more mundane motives of self-interest. Another text, *Magruder's American Government* by McClenaghan tells his impressionable readers that "individual initiative within the medical profession is extremely vital and must be preserved." If such a statement has any general meaning at all it would probably apply to any type of activity. However, its effects seem to be to warn

the student against socialized government "interference" in the field of medicine. Several of the texts pictured the Taft-Hartley law as badly needed legislation to curb the power of labor unions. Rarely recognizing the concentrated power of and influence held by managers and industrial groups. One text begins its chapter on the labor movement with introductory paragraphs concerning discussions of the "Dead horse" and "featherbed," the implications being obvious. Several texts include their discussion of labor activities in the same sections in which they discuss anarchists, radicals, and "reformers."

Conclusions

The present authors concluded that a sample of textbooks used in the West Virginia public schools system present the same problems of bias and distortion reported by Scoggins. They tend to be anti-labor, anti-government, anti-social welfare and to present our society as a perfectly functioning unit with out problems. An intensive review of sections dealing with these questions suggests that virtually all the texts could be regarded as anti-labor. While the limitations of this study in its use of individual judges rather than group data are recognized, the fact that evidence seems so consistantly and convincingly in like with expectations, suggests that labor groups, parents in the labor movement, and other interested parties should launch concentrated programs into evaluate and adjust the textbooks for fairer and more balanced presentations.

Textbooks Reviewed

- Smith and Benoit. *Economics For Our Times*.
New York: McGraw-Hill, 1966.
- Goodman and Moore. *Today's Economics*.
Boston: Ginn and Company, 1960.
- Crabbe, DeBrum and Haines. *General Business*.
Cincinnati: South Western Publishing Company, 1966.
- Bartlett, Fenton, Fowler and Mandelbaum. *A New History of the United States*.
New York: Holt, Rinehart and Winston, Inc. 1969
- Muzzy. *Our Countries History*.
Boston: Ginn & Company, 1961.
- Frost, Brown, Ellis and Fink. *A History of the United States*.
Chicago: Follett Ed. Corporation, 1969.
- Link and Muzzey. *Our American Republic*.
Boston: Ginn & Company, 1966.
- Dunwiddie. *Problems of Democracy*.
Boston: Ginn & Company, 1967.
- Landis. *Social Living*.
Boston: Ginn & Company, 1961.
- McClenaghan. *Magruder's American Government*.
Boston: Allyn and Bacon, Inc., 1964.
- Bragdon, Cole and McCutchen. *A Free People*.
New York: Macmillan Company, 1970.
- Sandler, Rozwenc and Martin. *The People Make A Nation*.
Boston: Allyn & Bacon, Inc., 1971.
- Coleman. *Comparative Economic Systems*.
New York: Holt, Rinehart and Winston, 1968.
- Calderwood and Fersh. *Economics in Action*.
New York: Macmillan Company, 1968.
- Rienow. *American Problems Today*.
Boston: D. C. Heath and Company, 1958.

Literature Cited

1. Alexander, Albert. March, 1969. "Does the American History Textbook Still Wear A Gray Flannel Cover?" *Social Education* 33:300-305.
2. Cook, Ronald E. 1969. The Attitudes of Secondary Schoolteachers Toward the American Labor Movement. Unpublished Masters Thesis. West Virginia University. Morgantown, West Virginia.
3. Doherty, Robert E. Spring, 1963. Attitudes Toward Labor: When Blue-Color Children Become Teachers. *The School Review* 71:87-96.
4. Nicholas, Arthur S., and Anna Ochoa. March, 1971. Evaluating Textbooks for Elementary Social Studies: Criteria for the "Seventies". *Social Education* 35:290-94.
5. Martin, John F. 1968. Attitudes of College Seniors Toward Labor Unions. Unpublished Masters Thesis. West Virginia University. Morgantown, West Virginia.
6. Moore, John Robert. March, 1969. State History Textbooks: *Essays in Ethnocentrism* *Social Education* 33:267-76.
7. Reese, Albert. 1965. The Economics of Trade Unions. University of Chicago Press. Chicago.
8. Scoggins, Will. 1966. Labor in Learning: Public School Treatment of the World of Work. California Institute of Industrial Relations. Los Angeles.

A Comparison Between Neurotics' and Normals' Perceptions of Interpersonal Exchange in Family Roles¹

Meir Teichman,* Yona Teichman
Fairmont State College
Fairmont, West Virginia 26554

and

Uriel G. Foa
Temple University
Philadelphia, Pennsylvania 19104

Abstract

It was hypothesized that hospitalized neurotics would perceive themselves as less involved in interpersonal exchanges in their family than normals: They would perceive themselves as giving and getting less interpersonal resources such as love (affection) and status (esteem) than normal Ss.

Male and female, neurotic and well-adjusted Ss from Banaras, India and Athens, Greece have been individually tested with the Role Behavior Inventory (Foa, 1966). As predicted, Ss' perception of the amount of interpersonal resources exchanged in their relationships with spouse and parents were found to be significantly lower for neurotics than for normals regardless of Ss' sex.

*Now at Tel-Aviv University, Tel-Aviv, Israel.

¹The preparation of this paper was supported, in parts, by Grants GS-2094 and GS-29193 from the National Science Foundation (Uriel G. Foa, principal investigator).

One of the most agreed symptom of maladjustment is a restriction in the amount of interpersonal exchanges in which the person gets involved. So far, this description has been made mainly on the basis of clinical observations and evaluations. This study aimed to confirm it empirically as well as to point out that neurotics are cognitively aware of their restricted interpersonal experiences.

The hypothesis stated that hospitalized neurotics would perceive themselves as less involved in interpersonal exchanges in their family than normals: They would perceive themselves as giving and getting less interpersonal resources such as love (affection) and status (esteem) than normal Ss.

Method

Subjects

Subjects were neurotics and well-adjusted males and females from Banaras, India (n=79) and Athens, Greece (n=100). The neurotics were middle-class hospitalized patients. To match the patients' socioeconomic level, the well-adjusted Ss have been randomly chosen from middle class population in Banaras and Athens. None of the Ss was abroad or intensively exposed to Western culture.

Instrument

Ss perceptions of interpersonal exchanges with parents and spouses were assessed by the Role Behavior Test (Foa, 1966). The test records perceptions of interpersonal behaviors in a role (Foreman-Worker). In the present study, the Indian samples recorded perceptions relevant to the major family roles (Husband-Wife; Son-Father; Son-Mother; Wife-Husband; Daughter-Mother; and Daughter-Father) while the Greek samples recorded only the perception relevant to marital roles (Husband-Wife; Wife-Husband).

The test covers 64 specific behavioral variables which were derived from a combination of six behavioral and six perceptual facets. Each variable is represented in the test by three semi-projective items which are scattered randomly in the test. The items are short descriptions of a given reciprocal role. Following description the S is asked to state the frequency of occurrence of the described behavior on a five point scale (0 to 4). The sum of points is the variables's score. The range of scores, is from 0 to 12 for each variable. Zero represents lack of perception of the described behavior, while 12 represents perception of high occurrence of the behavior.

The data presented in this study is based on 32 variables, which depict the perceptions of giving and receiving love and status in the different reciprocal roles.

The differences between the means for the two groups were tested for significance by t-test for two independent samples.(3)

Results

The results presented in tables 1 and 2 indicate that in the Indian samples, regardless of subjects' sex, the perceived amount of resources exchanged with spouses and parents is significantly lower in the neurotic group than in the well-adjusted one. The neurotics perceive themselves as giving less love and status to their spouses and parents and receiving less.

Table 3 shows the same pattern of perceptions of exchanges in marital relationships for the Greek sample.

Table 1. Means Comparisons of Ss' Perceptions of Her Behaviors Toward the Other and Other Behaviors Toward Her in Neurotic and Normal Indians.

<i>Role</i>	<i>Variable</i>	<i>Subject to Other</i>			<i>Other to Subject</i>		
		<i>Neurotics</i>	<i>Normals</i>	<i>D</i>	<i>Neurotics</i>	<i>Normals</i>	<i>D</i>
Wife— Husband	gS ^a	6.20	9.10	-2.90*	5.20	8.31	-3.11*
	gL ^b	6.00	9.79	-3.79*	4.50	9.21	-4.71*
Daughter— Mother	gS	5.50	9.35	-3.85***	4.93	8.09	-3.16**
	gL	6.89	10.15	-3.36***	6.71	9.44	-2.73*
Daughter— Father	gS	5.55	8.92	-3.37**	6.55	8.71	-2.15*
	gL	7.45	9.94	-2.49*	5.55	8.92	-3.37***

* $p < .05$ two tailed
 ** $p < .01$
 *** $p < .001$

a. giving status
 b. giving love

Table 2. Mean Comparisons of Ss' Perceived Behavior Toward Other and Other Behaviors Toward Him in Neurotic and Normal Indian Male Ss.

Role	Variable	Subject to Other			Other to Subject		
		Neurotics	Normals	D	Neurotics	Normals	D
Husband— Wife	gS	7.87	8.05	- .18+	6.67	9.84	-3.17**
	gL	8.56	8.82	- .26	7.83	10.68	-2.85**
Son— Father	gS	7.48	8.89	-1.41	6.08	8.35	-2.27**
	gL	7.84	10.24	-2.40**	7.08	9.53	-2.45**
Son— Mother	gS	7.48	9.16	-1.68*	6.14	8.12	-1.98*
	gL	7.67	9.68	-2.01**	7.29	9.24	-1.95*

+ $p < .10$

* $p < .05$

** $p < .01$

Table 3. Mean of Ss' Perceptions of Their Behavior Toward The Spouse and Spouses' Behavior Toward Them in Patients and Normal Greek Ss.

Role	Variable	Subject to Other			Other to Subject		
		Neurotics	Normal	D	Neurotics	Normals	D
Subject— Spouse	GS	5.97	8.31	-2.34**	6.87	8.21	-1.34*
	GL	9.43	9.38	+ .05	9.47	9.97	- .50

* $p < .05$

** $p < .01$

Discussion

Neurosis represents the way of life an individual has chosen in order to reconcile his feelings of inadequacy. The subjective solution may differ, however, there is one common outcome which, as indicated in this study, proves to be cross-cultural. This outcome is the restriction of social interaction, including interaction with significant others. The direct approach of this problem seems to be a goal of major importance. The instrument which was described may help to identify problematic aspects of any given social interaction, and to set hierarchies for treating them. The application of social learning principles to such problems rather than to specific ones seems to be the challenge of the future.

Literature Cited

1. Foa, U. G. 1966. Perception of behavior in reciprocal roles: The Ringex Model. *Psychological Monographs* 80 (15, Whole, No. 623).

Introversion, Extraversion and Free Recall Learning

Ronald N. Bone

Department of Psychology

West Virginia Wesleyan College

Buckhannon, West Virginia 26201

Abstract

Extraverts and introverts learned either a list of 10 high or low formal similarity trigrams by free recall for seven trials. Since previous research suggests extraverts are resistant to response competition it was predicted extraverts would exhibit superior performance on the high, but equal performance compared to introverts on the low similarity list. Predictions were not confirmed. Introverts did, however, exhibit superior performance on the low similarity list and equal performance, compared to extraverts on the high similarity list.

Recently McLaughlin and Eysenck (1967) have demonstrated the performance of extraverts superior to introverts on both easy and difficult paired-associate tasks. These results were theoretically interpreted in terms of introverts possessing higher cortical arousal which facilitated consolidation of incorrect along with correct responses and therefore interfered with the integration of the lists.

Further support is suggested by Jensen's (1964) factor analytic study of learning tasks and personality variables. Basically he found extraverts superior to introverts on tasks containing interference. Jensen (1964) interpreted his results by assuming extraverts are more resistant to response competition.

Since Eysenck's (1967) theory has been found to be applicable to paired associate (McLaughlin *et al.* 1967) and serial learning (Jensen, 1964) it is appropriate to extend the generality of these findings to another verbal learning task,

free-recall learning (Tulving, 1962). It was predicted that the effects of extraversion-introversion would be more apparent on a difficult (task containing interference) than an easy task, and that extraverts would exhibit superior performance on only the difficult task.

Method

Materials. Two lists of 10 low association trigrams (0.0%-20.0% Glaze values) of high and low formal similarity were chosen from the Underwood & Richardson (1956) study.

Subjects. The Ss were students enrolled in introductory psychology classes at West Virginia University. Two groups of 20 Ss each were selected on the basis of extreme scores from 120 students that had previously taken the Maudsley Personality Inventory (Eysenck, 1959). Twenty Ss in each of the extraversion and introversion treatments were randomly divided into two groups to learn either easy or difficult lists. Mean extraversion and introversion scores were respectively 38.50, 39.01 and 12.56, 12.22 for easy and difficult lists.

Procedure. Each of the four treatments were tested separately with a group testing procedure. At the beginning of the task *E* read standard free-recall instructions and answered any questions Ss raised. Each trigram was individually presented for 1-sec. by a slide projector with approximately one second between each item. Thirty seconds were allowed for Ss to write down their responses. Throughout testing seven learning trials alternated with seven test trials. The data were analyzed in a 2 x 2 x 7 factorial design involving extraversion-introversion, list difficulty (high and low similarity) and trials as a repeated measure.

Results

Table 1 provides the mean correct responses over seven trials for each of the four treatments.

Table 1. Mean Correct Responses Over Trials.

	Trials						
	1	2	3	4	5	6	7
Extraverts High Similarity	1.9	2.7	3.0	2.9	3.2	4.0	3.6
Extraverts Low Similarity	1.7	2.7	3.6	3.7	4.7	4.8	4.8
Introverts High Similarity	2.0	2.3	3.2	2.9	3.9	4.0	4.4
Introverts Low Similarity	2.2	4.6	5.3	5.4	6.0	5.9	6.6

The results of an analysis of these data are listed in Table 2. The only significant findings were those of the main effect of list where performance was superior on low as opposed to high similarity lists. Trials was also significant demonstrating learning occurred. Also performance was superior on the low as opposed to high similarity list over trials. Contrary to predictions, introverts outperformed extraverts, although this fell short of significance ($p < .10$).

Discussion

The present data lend no support to the hypothesis that extraverts would exhibit superior performance to introverts on difficult (high similarity or interference lists) but exhibit similar performance on easy or low similarity lists.

Table 2. Analysis of Variance for the Correct Response Data.

Source of variation	d.f	M.S.	F	P
Between subjects				
Extraversion (A)	1	46.41	3.90	.10
List (B)	1	115.71	9.70	.01
AxB interaction	1	26.40		
Error between	36	11.93		
Within subjects				
Trials (C)	6	41.62	37.84	.001
AxC interaction	6	1.05		
BxC interaction	6	3.75	3.40	.01
AXBxC interaction	6	1.09		
Error within	216	1.10		

However, it should be noted that a trend was observed in the opposite direction of introverts exhibiting overall superior performance, although this effect was confined to the low similarity list.

It is difficult to reconcile these findings with those of other studies (McLaughlin *et al.* 1967) demonstrating superior performance of extraverts. Possibly the addition of extra trials would have confirmed the hypothesis. However, an inspection of Table 1 gives no suggestion that this would have been the case; in fact additional trials would probably have the effect of intensifying the superiority of introverts over extraverts, at least on the low similarity list.

Conceivably the learning of a free-recall task differentially favors introverts over extraverts. For instance, organizational tendencies have been noted over trials (Tulving, 1962) and introverts may be better able to organize higher order units. Unfortunately the use of trigrams led to such low amounts of organization that an analysis was not performed. However, it should be noted that introverts were superior on the low similarity list where organizational tendencies would more likely be utilized.

Literature Cited

1. Eysenck, H. J. 1959. *Maudsley Personality Inventory*. London: University of London.
2. ———. 1967. *The Biological basis of personality*. Springfield: Thomas.
3. Jensen, A. R. 1964. Individual differences in learning: interference factor. Co-operative Research Project No. 1867. Office of Education, U. S. Department of Health, Education and Welfare.
4. McLaughlin, R. J., and Eysenck, H. J. 1967. Extraversion, neuroticism and paired-associates learning. *J. exp. res. Pers.* 2:128-32.
5. Tulving, E. 1962. Subjective organization in free recall of "unrelated" words. *Psychol. Rev.* 69:344-54.
6. Underwood, B. J., and Richardson, J. 1956. The influence of meaningfulness, intralist similarity, and serial position on retention. *J. exp. Psychol.* 52:119-26.

Birth Order and Creativity

Ronald N. Bone

*Department of Psychology
West Virginia Wesleyan College
and*

Barbara B. Griswold

*Charles F. Read Zone Center
Buckhannon, West Virginia 26201*

Abstract

Creativity scores were used as the dependent variable in a 2 x 2 x 3 design involving sex, birth order and family size. Contrary to predictions the oldest child was found to be more creative than the youngest, though this fell short of significance. In addition, family size exerted a depressing effect on creativity for the youngest child, and females were more creative than males. Consistent with predictions, creativity was higher in female than male only children.

Recently Eisenman (1964) found first-born college art students to be less original and artistically creative than later born students using the Creative Design Test to assess creativity. Eisenman interpreted his results as being supportive of an hypothesis derived from Adler (Ansbacher & Ansbacher, 1956) and Schachter (1959) that the first born, being more conservative and conforming than the later born, would be less original and artistically creative than the later born.

While Eisenman's (1964) sample was too small to meaningfully investigate sex differences, recent evidence suggests that sex differences may exist, at least for only children. While not investigating creativity, Sampson & Hancock (1967) found only-child males scored higher in conformity than only-child females. Following Eisenman's (1964) reasoning it could be predicted that female only children are more creative than male only children.

The purpose of this study was to extend Eisenman's (1964) findings with respect to first borns being less creative than later borns, and to explore systematically the nature of the relationship of two other variables family size and sex.

Rather than lump everyone into the catchall category of later born, this study differentiated between the oldest and youngest child in two, three and four sibling families. The middle child was excluded from the analysis because as family size increases beyond three siblings the definition of a middle child becomes ambiguous.

While no definitive predictions concerning family size can be made regarding creativity, Bossard & Boll (1966) suggest that in large families emphasis is placed upon the group and not the individual which results in lack of opportunity to develop individual potentials. In contrast, they view the small family as emphasizing the development of the full potentials of each member. It was therefore

tentatively predicted that family size would have a depressing effect upon creativity.

In addition to birth order, another test of creativity, the Remote Associates Test (RAT) devised by Mednick (1962) was used. A separate analysis of male and female only children was conducted with the prediction of the latter scoring higher in creativity.

Method

The subjects used were 219 introductory psychology students (117 males and 102 females). All subjects had previously taken the RAT. Birth order information was obtained by passing out a questionnaire several weeks after the test was given. No subject was included in the analysis that had step brothers or sisters, nor was anyone included that had a twin in their family.

A $2 \times 2 \times 3$ analysis of variance with subjects classified according to sex; birth order (oldest versus youngest) and family size (two, three and four sibling families). RAT scores were used as the dependent variable. For this analysis means and number of subjects per treatment are presented in Table 1. Since unequal n 's resulted, a statistical procedure suggested by Myers (1966) involving expected cell frequencies was used.

Table 1. Mean RAT Scores and Number of Subjects Per Group

		2 Siblings	3 Siblings	4 Siblings
Males	Oldest	15.15	13.25	14.27
		(39)	(20)	(15)
	Youngest	12.85	13.09	12.40
		(27)	(11)	(5)
Females	Oldest	15.35	16.60	15.20
		(26)	(25)	(10)
	Youngest	15.82	13.87	14.25
		(22)	(15)	(4)

Results

Birth order approached but did not reach significance, ($F=3.52$, $df=1/207$, $p<.10$). Unexpectedly the oldest child was more creative than the youngest which is in opposition to Eisenman's (1964) finding of the older child being less creative than the later born. Family size was nonsignificant ($F<1$), though sex was significant, ($F=5.91$, $df=1/207$, $p<.05$) with females being more creative than males.

The family size x birth order interaction was significant ($F=13.53$, $df=2/207$, $p<.001$) with the oldest child maintaining a consistently higher level of cre-

ativity than the youngest child as family size increases. While family size exerted a slightly depressing effect on the older child's creativity, there was a trend for the younger child's scores to more markedly decline as family size increased, thus lending some support to Bossard, *et al.*, (1966) for younger children. Duncan's test, however, yielded nonsignificant comparisons in all instances. The family size x sex interaction was significant ($F=14.25$, $df=2/207$, $p<.001$) with progressive decreases in creativity for females as family size increased. For males creativity decreased from two to three sibling families, but tended to increase for four sibling families. Females, however, maintained consistently higher creativity which was significantly different from males ($p<.05$) only in three sibling families. Both the birth order x sex and the family size x birth order x sex interactions were nonsignificant with ($F=1.23$, $df=1/207$) and ($F=1.41$, $df=2/207$) respectively.

A separate analysis comparing mean RAT scores for 13 male and 19 female only children (12.00 and 15.53 respectively) yielded a statistical significant $t(30)=2.46$, $p<.01$, supporting the prediction of female only children being more creative than male only children.

In comparing only children with the main analysis it is interesting to note that in terms of creativity only child females are comparable to the oldest females regardless of family size (see Table 1). In contrast, only child males do not resemble oldest child males, but more clearly resemble youngest male children. Theoretically, however, only children can as justifiably be classified youngest as oldest (Warren, 1966) so problems of comparison are tenuous.

In conclusion, while the results failed to reach an appreciable level of statistical significance, no support was achieved for Eisenman's (1964) finding of first borns being less creative than later borns, in fact a reverse trend was obtained with the oldest child being more creative than the youngest. However, these results cannot be taken as complete refutation of Eisenman's (1964) study considering the differences between the Creative Design Test used by Eisenman, and the RAT used in this study. In addition, Eisenman used the category of "others" which included a much more heterogeneous group of subjects than our use of the youngest child. One might argue that inclusion of middle children could alter the results, but essentially the same findings were obtained in an oldest-other analysis such as Eisenman (1964) used.

Also, the Bossard, *et al.*, (1966) hypothesis of family size exerting a depressing effect in the development of individual potential was given minimum support. However, other factors such as birth order should be investigated as interacting with family size.

Of particular interest was the finding of female only children being more creative than male only children. It is suggested that only children, in themselves, warrant further study with respect to creativity.

Summary

Creativity scores were used as the dependent variable in a $2 \times 2 \times 3$ design involving sex, birth order (oldest versus youngest) and family size (two, three and four sibling families). Contrary to predictions the oldest child was found to be more creative than the youngest, though this fell short of significance. In addition, family size exerted a depressing effect on creativity for the youngest child, and females were more creative than males. Consistent with predictions, creativity was higher in female than male only children.

Literature Cited

1. Ansbacher, H. L., and Ansbacher, R. R. (Eds.) 1956. *The Individual Psychology of Alfred Adler*. New York: Basic Books.
2. Bossard, H. S., and Boll, E. S. 1966. *The Sociology of Child Development*. New York: Harper & Row.
3. Eisenman, R. 1964. Birth order and artistic creativity. *Journal of Individual Psychology* 20:183-85.
4. Mednick, S. A. 1962. The associative basis of the creative process. *Psychological Review* 69:220-32.
5. Meyers, J. L. 1966. *Fundamentals of experimental design*. Boston: Allyn and Bacon.
6. Sampson, E. E., and Hancock, F. T. 1967. An examination of the relationship between ordinal position, personality, and conformity: An extension, replication, and partial verification. *Journal of Personality and Social Psychology* 5:398-407.
7. Schachter, S. 1959. *The Psychology of Affiliation*. Stanford: Stanford University Press.
8. Warren, J. R. 1966. Birth order and social behavior. *Psychological Bulletin* 65:38-49.

External Commitment Effect as a Function of Need for Social Approval

Julia Ann Greenwood and George Ward II
Department of Psychology
Marshall University, Huntington, West Virginia 25701

Abstract

The present study investigated the relationship between need for social approval and opinion change due to external commitment. One hundred and eleven university students were administered a 30-item opinion questionnaire and divided into two groups on the basis of their scores with a median split on the Marlowe-Crowne Scale. Three weeks later, the Ss performed paper and pencil tasks under instructions that skilled professionals would examine their responses and predict their opinions on other topics. One week hence, the results of the "professional's judgments" were returned to the Ss, who were asked to indicate their actual opinions adjacent to the printed professional's estimates. Twelve items from the original questionnaire were included. Any change between the two opinion responses was defined as opinion change due to external commitment effects. External commitment was manipulated to form three levels, "incongruent," "congruent," and "no commitment" across high and low social approval groups.

Analysis of results confirmed the occurrence of the external commitment phenomenon—when compared with the "no commitment" group, the "incongruent" group showed facilitation of change, and the "congruent" group resistance to change, both significant at the .01 level. Contrary to the hypothesis of the study, however, differences between high and low need for approval groups in external commitment effects were not significant.

The concept of "social desirability" was originally introduced in relation to response bias on personality tests (Cronbach, 1950) but has more recently been broadened to include non-test relevant behavior. Thus, Marlowe and Crowne (1960) invoked the definition of a "need . . . to obtain approval by responding

in a culturally appropriate and acceptable manner." The Marlowe-Crowne Social Desirability Scale (M-C SDS) was developed and has been employed in several studies for predicting differential behavior in a variety of experimental situations. Thus, Marlowe and Crowne (1964) reported that individuals dichotomized at the mean of M-C SDS scores into high and low groups showed different amounts of attitude change according to degree of personal commitment.

Commitment to an opinion as a factor in opinion change has been extended by Rosenbaum and Zimmerman (1959) to include two types, self-commitment and external commitment. Under the condition of self-commitment, the effects of a person stating an opinion are examined in terms of their influence on subsequent opinion change by the Ss. In the case of external commitment, commitment prior to the social influence attempt is from an external source rather than by the S himself.

External commitment was found by Rosenbaum and Franc (1960) to function similarly to self-commitment in both congruent and incongruent conditions. They administered external commitment under the guise of an experiment in social perception. In this procedure a non-existent professional person marked opinion items, supposedly according to his ability to perceive the probable opinions of the S. The opinion of the S obtained after he saw the "professional's" prediction of his opinion was compared with his original response. Any resulting change was regarded as due to the effect of external commitment. External commitment was manipulated through three levels of discrepancy with the S's original opinion, forming congruent, incongruent and neutral groups. Rosenbaum and Franc reported that their results supported the hypothesis that an attribution congruent with the recipient's current opinion produces resistance to influence while an incongruent attribution facilitates opinion change. Marlowe and Crowne's (1964) theory of approval motivation suggests that, if prior public attitudes cannot be recalled, high need for approval Ss would change their opinion in the direction of consistency with the "professional's" estimates of their opinion.

To explore this implication, the present study sought to examine opinion change under the three conditions of external commitment across high and low approval motivation conditions. It was hypothesized that: 1) in the incongruent condition, high need for approval would show more opinion change than low; 2) in the congruent condition, greater resistance or least opinion change was predicted for the high need group; and, 3) no difference was predicted between high and low groups under the neutral condition.

Method

Subjects

The Ss in this research were University students who volunteered to participate in what purported to be two separate projects. Due to the phasing of the study, an original group of 258 was reduced to 111 by the time of completion.

Materials

The Marlowe-Crowne Social Desirability Scale was used as a measure of approval motivation. Adaptations of the 12 opinion items employed by Rosenbaum and Franc (1960) composed the critical change items and were variously imbedded with irrelevant items and other materials. Opinion was registered on a 6-point scale with no neutral point.

Procedure

The M-C SDS and initial opinion form were administered to classroom groups under the guise of a comparison of a personality inventory and opinions. Later feedback was provided to the effect that the research was completed without impressive results. A month later, they were asked to participate in an experiment on social perception. Their responses to a variety of items from "originality" and intelligence tests were recorded to provide data for evaluating the perceptive ability of "professional persons who have to deal with others." It was explained that these professionals would study their responses and make judgments as to the probable opinion of the students on other topics. To this extent the format closely paralleled that of Rosenbaum and Franc. At this point the *Ss* were assigned to high or low approval need groups and to one level of external treatment. A week later, *Ss* were given a set of opinion statements which included the 12 critical items. For each statement two groups had the scale markings "predicted by the professional" and a scale to be marked. The congruent commitment group had the scales marked exactly as they had responded originally. The incongruent group placed the estimated response four units in the opposite direction from the *Ss*' original markings. The neutral group did not have a previously marked scale and were told to simply mark their responses to the items, that the professional's judgments would be added later. Finally, a short questionnaire was provided to register suspicions of a connection between the various phases of the study.

Results

An absolute change score for a particular *S* was computed by summation of any change in declared opinion occurring in the 12 critical items, regardless of sign or direction of this change. This amounted to a register of amount of opinion change. Table 1 compares the mean absolute change scores of high and low need for approval groups within each of the external treatment conditions. No significant differences resulted from the Duncan Range Test at the .01 level.

The Duncan procedure was then applied to include all pairwise comparisons among the groups. The result was that all comparisons other than those reported above were found to be significant at the .01 level. That is, all comparisons involving differences in external commitment were significant.

In view of a possible "boomerang" effect—changing in the opposite direction from that of the attempted change, directional change scores were obtained. A 2-unit change in the opposite direction from the change attempt received a

Table 1. Mean Absolute Opinion Change Scores for High and Low Need for Social Approval *Ss* in Three External Commitment Conditions.

Need for Approval	External Commitment Conditions		
	Congruent	No Commitment	Incongruent
High	6.35	15.69	26.17
Low	8.20	14.28	24.25

negative sign and was subtracted from the *S*'s total change score—providing a measure of change in the direction of the external commitment. Means of these

scores for the high and low social approval groups under incongruent conditions were compared by a simple *t* test, with no significant differences.

Discussion

Although these results did confirm past findings in regard to the external commitment phenomenon, there was no evidence favoring the prediction that high and low need for social approval *Ss* would respond differently under the commitment conditions. An explanation for this outcome could well be the inability of the paper and pencil Social Desirability Scale to predict these behavioral outcomes. The Marlowe-Crowne has not been uniformly successful in such applications and the results of the present study do not encourage its employment as a measure of approval need in predicting opinion change. A second possibility, is that *Ss* perceived the situation differently than intended in the design. Thus an *S* might recall his previous response and with high need for approval feel constrained to respond consistently with his prior opinion—disregarding the professional's judgment. An interesting point in the incongruent condition was that high need *Ss* produced slightly more "boomerang" responses as did low need *Ss*. At first glance, such responding would not be expected from high need persons. It is possible, however, that they did perceive the consistency requirement in this situation, and, responding to it committed more "boomerangs." In view of the guise involved in a study of this type, it should be noted that only two subjects indicated on their post-test questionnaires some suspicion that the various phases were actually part of the same study and were consequently dropped as participants.

Literature Cited

1. Cronbach, L. J. 1950. Further evidence on response sets and test design. *Educational and Psychological Measurement* 10:3-31.
2. Crowne, D. P., and E. Marlowe. 1960. A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology* 24:349-54.
3. Marlowe, D., and D. P. Crowne. 1964. The approval motive. John Wiley & Sons, Inc. New York. p. 239.
4. Rosenbaum, M. E., and I. M. Zimmerman. 1959. The effect of external commitment on response to an attempt to change opinion. *Public Opinion Quarterly* 23:247-54.
5. Rosenbaum, M. E., and C. E. Franc. 1960. Opinion change as a function of external commitment and amount of discrepancy from the opinion of another. *Journal of Abnormal and Social Psychology* 61:15-20.

Social Science Section

Attitudes of White Students Toward Matters of Forced Integration, Personal Intimacy and General Principles of Equality

John R. Warner, Jr. and Albin R. Gilbert

Department of Social Science

West Virginia Wesleyan College, Buckhannon, West Virginia 26201

Dana G. Cable

*Hood College, Frederick, Maryland**

Abstract

The context of the research project is the present mood of the American public regarding forced busing of children in order to obtain racial balance in the public schools. According to public polls and the results of voting for candidates who oppose busing, there is today a strong resistance to such forced busing.

Our research attempts to show that persons who oppose forced integration, though they may deny it, hold more negative attitudes toward matters of personal intimacy between whites and blacks than do those who support forced integration. The research indicates that this is the case, in terms of verbal responses to stimulus items regarding the two issues. In this sense, then, those who oppose forced integration are more "prejudiced" than they might like to believe.

Why do they think that the opposition to forced integration is not a position of racial prejudice? Perhaps the answer lies in the fact that on the stimulus items dealing with general principles of racial equality ("All men are created equal," etc.), both groups score about the same.

The research goes one step further, however, by making use of latency-weighted testing. Here we discover that at a deeper level there may not be such important variations between the two groups as there appears at the level of verbal response. Research confirms that prejudice is a learned response, but that those who are "prejudiced" are quite similar to those who are "unprejudiced" in terms of deeper feelings.

Since the historic Supreme Court Decision of 1954 (*Brown vs. Board of Education*), the federal, state, and local governments have passed and enforced numerous laws which have brought about integration in schools, neighborhoods, and public institutions.

There has been strong resistance to such governmental actions, and many persons believe that it is not the place of government to force integration. In his study of the 1963 School Committee election in Boston, Pettigrew (1971) reported that many of the voters who opposed integration did not like to think of themselves as bigots or as being prejudiced. Pettigrew's study suggests that there

*Research assistants were Philip Petrosky and Barbara Boltz.

is a discrepancy between what people say and their "inner-mind-attitude" (how they feel and unconsciously think on questions of race and integration.)

The present research attempts to uncover some of the discrepancies between verbalized and inner-mind-attitudes, and to determine whether on the verbal level, persons who oppose forced integration hold significantly different attitudes on questions of social intimacy than those who generally support forced integration.

The use of latency-weighted testing is new in the study of attitudes. So far as the authors know, it has never been attempted in this way before. The rationale of this technique is based on time-honored knowledge that subjects, as a rule, betray through long latencies (reaction times) cognitive-emotional blocks possibly underlying such items.

In order to get behind the verbal response, the research reported here makes use of a rationale developed by Gilbert (1961, 1963, 1965, 1966, 1970; Gilbert & Cable, 1967) on personality testing. The rationale recognizes what has long been known in psychological research, that subjects take longer to respond to anxiety-laden items than to items which do not bother them.

Methods and Materials

For the purposes of the present study it was necessary to develop a special testing instrument. The instrument consisted of a list of 48 statements patterned on three kinds of problems related to attitudes of racial prejudice. Sixteen items were patterned on the issue of forced integration; thirteen dealt with general principles of racial equality; and nineteen items dealt with interracial social intimacy and sex. The 48 items were placed randomly onto the testing instrument, but were unscrambled later for purposes of analysis. The stimulus items were composed at face value, but were then examined on content validity by subjecting them to three independent judges, members of the faculty within the Social Science division of the college. The three judges confirmed that the statements were in fact patterned after the three kinds of problems which they claimed to be.

Eighty white students from West Virginia Wesleyan College participated in the research project as subjects of the study. These subjects were tested individually by one of two especially trained research assistants. The assistant read the stimulus items to the subject. As the stimulus item was completed, the assistant pressed a button which set off a timer. The subject was instructed to press another button when prepared to answer, and this second button stopped the timer. After pressing the button, the subject answered "agree" or "disagree." The tester then entered the latency score (time) with annotation "agree" or "disagree" beside each question.

Each test item was scored on the verbal and latency responses. The test items were geared to non-prejudiced verbal responses. On each item the subject was given a score of "one" if his verbal response was non-prejudiced, and a "zero" if his verbal response was prejudiced. The total for each section of the instrument (forced integration, general principles, social intimacy) represents the verbal score for that section.

In order to establish latency scores, all obtained latency times were arranged in ascending order. The twelve longest (upper quartile) times were cut off and broken down into the three sections in which they appeared. The latency score

for each section was equal to the number of longest latency times recorded in that section.

Two criterion groups were developed based on the verbal scores on stimulus items dealing with forced integration. The "prejudiced" criterion group consisted of respondents who gave from two to nine positive responses to the statements favoring forced integration; the "unprejudiced" criterion group was composed of those who provided twelve to sixteen positive responses. This cut off resulted in eighteen subjects in the "prejudiced" group and twenty-three in the "unprejudiced" group. Subjects with ten or eleven positive responses were excluded from the criterion groups. A t-test was performed on the scores of each criterion group to determine that the groups were significantly differently ($p .001$).

Results

1. Subjects in the "prejudiced" criterion group do not differ significantly from those in the "unprejudiced" group in verbal responses to statements of general principles of racial equality ($t = 0.0959$, $df = 39$).

2. Subjects in the "prejudiced" group differ significantly from those in the "unprejudiced" group in *verbal* responses to stimulus items dealing with social intimacy and sex in interracial situations ($t = 3.1830$, $df = 39$, $p .01$). The mean positive response for the "unprejudiced" group was 15.09 (out of 19 stimulus items) and the mean positive response for the "prejudiced" group was 11.72.

3. Subjects in the "prejudiced" group did not differ significantly from those in the "unprejudiced" group in *latency* responses for any of the three sections of the instrument (integration: $t = 0.4731$; equality: $t = 0.2358$; intimacy: $t = 0.4238$; $df = 39$).

Discussion

It is apparent from the results of verbal responses that those who oppose forced integration verbally give significantly fewer positive verbal responses to questions of intimate interracial contact and are, in that sense, truly "more prejudiced."

The similarity between the two groups on verbal and latency responses on general principles of racial equality is not surprising, for in our day most people seem to agree on the principles of equality and claim, therefore, to be "unprejudiced." Thus was Pettigrew able to find many people who opposed forced integration while at the same time claiming to be unprejudiced.

The fact that there are significant differences between the criterion groups on verbal responses versus latency responses to stimulus items dealing with intimacy and sex, indicates an intriguing discrepancy between verbal and latency-responses. Could it be that at the cognitive-verbal level, subjects are more outspoken; while on the un verbalized (unconscious) level doubts, mental reservations, and the like, as reflected in the "projective" latencies, might prevail? The authors are examining this problem by depth-interviews of subjects and will discuss the results in a separate research report.

Our investigation has introduced a new method of investigating attitudes, namely that of latency-weighted testing. It contributes to our understanding of attitudes and adds a dimension which is not possible through the standard "paper-and-pencil" test alone. The latency-weighted method of testing allows the tester to obtain projective results quickly and efficiently, which are necessary elements in obtaining information on attitudes of large numbers of subjects.

Efficient equipment for latency-weighted testing is available by using the *Response-Latency Recorder*, manufactured by the Polymetric Company, Hoboken, New Jersey.

Literature Cited

1. Gilbert, A. R. 1961. The other person: how we "intend" it. *J. Psychol.* 51:247-62.
2. ———. 1963. Toward an automated technique of probing into emotional blocks. *J. Psychol.* 56:385-404.
3. ———. 1965. Timed cross-examination as an innovation in personality assessment. *Proc. W. Va. Acad. Sci.* 37:289-96.
4. ———. 1966. The diagnostic value of reaction-time applied to some scales of the Taylor Manifest Anxiety Scale. *Proc. W. Va. Acad. Sci.* 38:211-19.
5. ———. 1970. Superiority of latency-weighted scores over unweighted scores in testing patrolmen. *APA Experimental Publication System Dec.*, 9: Ms No. 343-2.
6. Gilbert, A. R., and Cable, D. G. 1967. Diagnostic value of reaction-time in different formats of personality items. *Psych. Reports* 20:69-70.
7. Pettigrew, T. F. 1971. *Racially separate or together?* New York: McGraw-Hill Book Co.

The Influence of Company Size on the Goals and Activities of Personnel Managers

Edward A. Johnson and Beryl A. Johnson

College of Business and Economics

West Virginia University, Morgantown, West Virginia 26506

Abstract

This study focusses on the goals and activities of personal executives in small and large companies in the United States and Canada.

The purpose of the study was twofold: (1) to obtain a better understanding of the relationship between personnel executives' goals and activities and (2) to detect whether the size of a company may be an important variable with respect to the goals and activities of personnel executives.

To develop some insight into the relationship between personnel goals and activities, questionnaires were sent to personnel executives asking them to identify (1) the main basic goals of their department and (2) the personnel activity which occupied the largest block of their personal time during the last two years.

The sample for the study was drawn from United States and Canadian firms listed in a recent edition of *Poor's Register of Corporations, Directors, and Executives*. Using a disproportional sampling technique, companies were selected in each of two size groupings: 500 to 999 employees (defined as a small firm) and over 5,000 employees (defined as a large firm). Within these size groupings, firms were selected at random as to geographical location and industry.

To assess whether there were any meaningful differences between the response patterns in small and large companies, three distinctions were made: percentage differences of 10 percent and over were classified as *great*; percentage differences which ranged between 5 percent but less than 10 percent were considered moderate; and any percentage differences of less than 5 percent were not classified as different. Although the data obtained in the

study were not tested for statistical significance, the three distinctions made above provided a general guide for the interpretation of whether there were meaningful differences between the responses obtained from small and large companies.

The data in the study indicate that there are no substantial differences in the distribution of goals when analyzed by size of company. Both groups of personnel executives are more concerned about programmatic goals than they are about broader corporate goals.

The data also suggest that personnel executives in both size groups are devoting most of their time to activities other than those for which their goals are set.

In general, the data provides evidence that the size of company is not an important variable with respect to the goals and activities of personnel executives.

A Consideration of Some Sociological Variables Associated With Attitudes Towards Women's Rights¹

Alvar L. Nieves and Meir Teichman*

Fairmont State College, Fairmont, West Virginia 26554

Abstract

The present study attempts to empirically differentiate between women holding positive and negative attitudes about women's rights and examine some of the background correlates involved.

Hypotheses predicted relationships between attitudes toward women's rights and such variables as age, income, education, social status, and social activities.

Questionnaires were administered to 50 female subjects in Fairmont, West Virginia and nearby communities. The data supported the predicted relationship between attitudes toward women's rights and age, education, social position, social activities and leisure pursuits. No relationships between subjects' attitudes and family-income, and social mobility were found.

Increased awareness of the Feminist movement in both popular and professional publication is evident from the flood of new material currently available. Much of the recent literature may be categorized in three major areas: historical, philosophical and contemporary. Analysis and discussion within each of these areas has largely been concerned with the documentation of antecedent and existing inequities to which women have been and are subjected.

Empirical analyses from the strict orientation of the social scientist concerned with sociological and psychological variables have been fewer. One recent study (Worrell & Worrell, 1971) examined some personality correlates of supporters and opponents of the Women's liberation movement. The purpose of the present study is to add a sociological dimension to the understanding of the differences between women who support and oppose the Women's Rights Movement.

*Now at Tel-Aviv University, Tel-Aviv, Israel.

¹The authors wish to thank Carol Lemley for her assistance. Requests for reprints should be sent to the first author.

The Women's Rights Movement introduces a different viewpoint about the status of women in her family as well as in the wide society and proposes the restructuring of our society. Thus, the Women's Rights Movement emphasizes changes in the social position of the woman. Based on Gans' (1965) and Lewis' (1966) formulations about the lower class life styles and attitudinal approaches, it was hypothesized that women's attitudes about women's rights will be negatively associated with the respondents' age and positively with their family income, education, and social status (social position and upward mobility).

Following Alport's (1954) suggestion that there are direct relationships between structural heterogeneity and prejudice, it is proposed that as social interactions of the woman increases, including leisure pursuits, attitudes toward women's rights will become more favorable.

Method

Sample

The sample consists of fifty (50) females residing in Marion and Harrison counties, West Virginia. The respondents' age range from 20 to 65, with 58% below the age of 39 and 42% above. Seventy percent of the women were married, 18% single and 12% separated, divorced or widowed. Only 6% of the respondents hold professional positions, 34% service and clerical positions, 46% reported being housewives and 14% students. Most respondents reported an annual family income of less than \$8000 (60%). Correspondently, 70% of the respondents occupied a low social position according to Hollingshead Index of Social Positions.

Instrument

The sociological data were obtained through interviews conducted by student interviewers trained by the authors.

In addition, a questionnaire was administered to determine the respondents attitudes toward women's rights. This instrument was an attitude scale of the Likert type, constructed and tested by the authors. Of the one hundred items on the preliminary scale, 20 items which were statistically shown to discriminate between high and low quartiles, were included in the final form of the questionnaire.² Examples of statements used in the attitude instrument include: Women should not take an active interest in community affairs; Women change their minds too often; They have no confidence in their judgment; Men are lucky to be born as males; and a wife may make suggestions but important decisions should be made by the husband. Its split half reliability was $r = .76$ ($n = 36$).

Results

Based on the assumptions that receptivity to change varies inversely with age it was hypothesized that age will be negatively related to attitudes toward women's rights: (a) women whose age is above the median will hold more negative attitudes than younger women.

A second assumption, based on the belief that a relationship exists between attitudes and such variables as Income, Education and Social Position suggested the following predictions: (b) Women whose family income is below the average will show more negative attitudes than those with higher family income. (c)

²You may obtain a complete questionnaire by writing to the first author.

Women who have at least some college education will hold more positive attitudes than women without college education. (d) Women whose social status, as measured by Hollingshead's index of social position is 3 (middle class) or higher, and those who have reported upward mobility hold more positive attitudes about women's rights, while subjects occupying lower social positions will hold negative attitudes.

The last prediction is based on the assumption that the wider an individual's range of contacts and social experiences the greater will be her exposure to new ideas and her willingness to accept social change. Thus (e) Women who participate in at least two social activities and indicate at least two different leisure pursuits will tend to hold more positive attitudes towards women's rights than non-participants.

Our predictions were generally confirmed. The age of the respondent was found to be negatively related to attitudes toward women's rights. Significantly more women, who reported unfavorable attitudes about women's rights, were found to have less education and occupy a lower social position than women, who indicated they favored the women's rights movement. (See Table 1.) The frequencies of participation in community, social, and leisure activities were also

Table 1. Some Demographic and Sociological Variables and Females' attitudes Toward Women's Rights.

	<i>Attitudes Variable</i>	<i>Above Median</i>	<i>Below Median</i>	<i>Significance</i>
Age	Up to 39	19	10	$\chi^2 = 5.25$
	40+	6	15	$p < .025$ one tail
Education (years)	13+	14	5	$\chi^2 = 5.43$
	less than 12	11	20	$p < .01$ one tail
Social Position*	3 and above	11	4	$\chi^2 = 3.43$
	4 and below	14	21	$p < .05$ one tail
Community and Social Activities	2 and more			$\chi^2 = 3.93$
	1 or less	9	17	$p < .025$ one tail
Leisure	2 and more	17	9	$\chi^2 = 3.93$
	1 or less	8	16	$p < .025$ one tail

*Based on Hollingshead Index of Social Position.

found to be significant in differentiating between women who favor the women's rights movement and women who disagree with it. Women, who reported favorable attitudes, participated in more social and leisure activities than those whose attitudes were less favorable. Both variables may be viewed as indicators of an increase in the frequency of social interaction and the variety of information and experience to which individuals are exposed.

Contrary to our predictions, family income and social mobility were not found to be significantly related to the dependent variable. Relative to family-income, the nonsignificance may be a result of inconsistency between family-income and overall life style patterns of our sample. Some of our high income subjects were found to be of lower social position (laborers). Some higher status respondents, on the other hand, reported lower income due to retirement, or other exigencies.

Although social mobility does not statistically differentiate between subjects with positive and negative attitudes, the results indicate that there is a trend in the predicted direction.

Conclusion

The importance of role as a touchstone upon which individuals base their perception of self is generally recognized. It is through role enactment that one's social position is validated, self-system maintained, self concept heightened, reciprocal behavior elicited, and positive reinforcement is produced (Allen, 1968).

When alternatives are restricted, whether because of lack of education, interactive opportunities or finances, one must tenaciously hold to whatever security providing role is available.

Among middle and upper strata relinquishing one's beliefs concerning women (sex-derived social position) does not appear as threatening as in lower strata where homogeneity of experience tends to limit interactive alternatives.

The results obtained from the present study seem to substantiate the importance of role in relation to attitudes. Certainly this appears to be the case when alternatives are severely lacking. This appears to explain, for example, why social, community and leisure activities are positively associated with attitudes of women toward women's rights.

It seems likely that as mobility becomes more pervasive greater sex-role changes will be seen. Indeed, the recent passage of the Equal Rights Amendment may portend such change.

Literature Cited

1. Allen, V. L. 1968. "Role Theory and Consistency Theory." In R. P. Abelson, et al. (Eds.), *Theories of Cognitive Consistency: A Sourcebook*. Chicago: Rand McNally.
2. Allport, G. W. 1954. *The Nature of Prejudice*. New York: Doubleday.
3. Gans, H. J. 1965. "Subcultures and Class." In L. A. Ferman, et al., *Poverty in America*. Ann Arbor: University of Michigan Press.
4. Hollingshead, A. B. 1971. "Two Factor Index of Social Position." In Haug, M. R. and M. B. Sussman, "The Indiscriminate State of Social Class Measurement." *Social Forces* 49: 4:549-63.
5. Lewis, Oscar. 1966. "The Culture of Poverty." *Scientific American* 215: 4:19-25.
6. Worrell, J., and L. Worrell. 1971. "Supporters and Opposers of Women's Liberation: Some Personality Correlates," Paper presented at the annual convention of the American Psychological Association.

A Study of Attitudes Toward Poverty and Unemployment By Unionists and Managers¹

Paul Ridgely

Department of Social Science

Fairmont State College, Fairmont, West Virginia 26554

Abstract

The major thrust of the study is to extend the study of unemployment. Previous research has shown that attitudes about poverty are not merely randomly distributed throughout the social system but rather social explanation of poverty and unemployment are selectively distributed, and these attitudes can be located within specific socio-economic strata of society.

Does the identification of such attitudes aid in selecting methods of change aimed at the resolution of poverty and unemployment? With class associated and interest-group crystallized in the larger society how can programs based upon middle-strata interests (those traditionally attempted) be effective in changing lower-strata groups who are locked in on unemployment? Some kind of answer probably lies in influential types of persons amenable to change.

With this perspective, it was decided that two industrially based groups (union activists and managerial personnel) be sampled to a) describe those variables which predict the rationale endorsed to account for the cause of unemployment and b) to estimate the usefulness of empirically selective procedures in order to develop an understanding of how the prevailing system of attitudes toward melioration and strategies of change can influence the range of options open for programs aimed at re-employment and reduction of poverty.

On these basic ideologies, ways of handling unemployment, have been described for both union activists and managerial personnel. The concluding remarks deal with current approaches, both theoretical and applied, to unemployment; and based upon the type of program support indicated by the two study groups recommendations have been made.

Introduction

Sociologists hold that men act on the basis of their definition of situation and that social definition of another not only affects overt behavior, but arouses expectations toward them. This study focuses on some social and social psychological attributes that are related to the social typification of the unemployed and the poor subscribed to by first-line supervisors and active unionists, that is by incumbents of two key positions in industrial society. We know now that unemployment and poverty are not independent social maladjustments, but frequently coincide in a way of life of a sizeable segment of the American population. No meliorative program can fail to take this into account. Yet the final success of any planned change aimed at the alleviation of this problem is, in considerable measure, involved with the work world. Both unionists and supervisors participate actively in the fabrication and definition of work roles. The manner in which they account for the "causes of unemployment" and "reasons

¹I am indebted to Dr. Robert Miller, Director of the Office of Research and Development, Appalachian Center, West Virginia University, for providing the data used in this study and for his assistance throughout the research. I also wish to express my gratitude to Dr. Ronald Althouse, Associate Professor of Sociology, West Virginia University, for his critique and general support for the research.

for poverty" probably influences the reception of programs of re-employment of men without work and it would seem, the successful implementation of "poverty" programs.

Useful research can describe who will be partisans to particular programs and what can be done to crystallize partisan endorsement and support for them. For example, some studies suggest that greater support for programs which change established social conditions can be expected from individuals in the lower educational, occupational, and income levels. Significantly less support can be expected from persons in higher social levels, yet approval from persons occupying such levels is necessary in order to gain support and bring resources and organization into play, so as to resolve these problems.

In a recent study of attitudes toward the unemployed, Miller, Zeller, and Blaine (Miller, et al., 1968) showed that each successively higher level of education contains a larger percentage of members likely to attribute joblessness to personal failings of the unemployed, and a lesser percentage to recognize those factors beyond individual control. They also report that: 1) such an explanation of unemployment based on personal failure is associated with occupational status and 2) with income levels.

Of course, it would be dangerous to generalize uncritically from these findings; yet the data does show it is important to explore sources of beliefs concerning causes of unemployment, because aside from contributing to existing literature about social class and belief structure, the tendencies revealed, if widespread, have serious consequences for any practical applications in long range success of anti-poverty programs.

This paper attempts to describe some bases as to why influence may be forthcoming on some programs in relation to industrial-based businessmen and unionists; it examines them in relation to their attitudes toward "causes of unemployment."

Materials and Methods

Data was collected in 1967 through a questionnaire administered to a sample of union members and managers. The sample completed a questionnaire under the auspices of the Institute of Labor Studies at West Virginia University and through a similar organization at Ohio State University. All respondents were participating in a non-credit, off-campus, leadership training program. Although two union samples were drawn from Ohio and West Virginia, there were no significant differences between them on any item; they were combined to increase the total size to 300.

A similar questionnaire was administered to managers and supervisory personnel in small business-management associations throughout West Virginia, the total sample size is approximately 300.

As a procedural method, the Automatic Interaction Program (A.I.D.), was applied to identify those variables which possess the strongest predictive association with the dependent or criterion variable. The research criterion was the kind of comprehensive rationale endorsed to account from a man's condition of poverty or unemployment.

"The program is useful in studying the inter-relationships among a set of up to 37 variables. Regarding one of the variables as a dependent variable, the analysis employs a nonsymmetrical branching process, based on the variance techniques, to subdivide the sample into a series of subgroups

which maximize one's ability to predict values of the dependent variable. Linearity and additivity assumptions inherent in conventional multiple regression techniques are not required."²

Results and Discussion

In a national opinion sample, polled in 1964, 54 percent of the respondents reported that poverty was caused by a lack of effort on the part of individuals; about 46 percent of the national poll cited circumstances as reasons for poverty and unemployment. We asked a similar question of the unionist and businessmen. Most of the managers (75 percent) endorsed the idea that it is an individual's own fault if he becomes unemployed. By way of contrast, nearly three-fourths of the unionists felt that conditions leading to any one person's unemployment are beyond immediate personal control. If our samples are combined, findings reflect those carried out by the Gallop poll; however, the advantages of separating them in order to determine what sorts of consequences may exist for an active effort to apply unemployment policy are dramatized by the sharp distinction between active union members and industries managers and supervisors. With most businessmen assigning the "causes" to an individual level it hardly seems possible to expect them to endorse any program which encourages redistribution of wealth and societies resources; instead, such a rationale is much more apt to express an appetite for programs aimed at retraining the unemployed or even wiping out compensation for the unemployed.

A. Managers and Industrial Supervisors

Having established our criterion variable as the rationale endorsed to account for unemployment and poverty, the AID analysis was generated for managers and supervisors. They overwhelmingly rationalize unemployment as personal failure or fault, and the most pressing issue becomes what to do about it. Thus, the policies aimed at reducing unemployment partitioned the managers into two remedial plans aimed at resolving the issues of the unemployed. Some 30 percent of the managers proposed either cutting welfare payments or eliminating automation; while almost 79 percent indicated that economic pump-priming and a healthy economy geared to provide opportunities for jobs should be the paramount aims of program.

For managers who wished to eliminate automation or cut welfare allotments (both of which deals with pooling cheap labor reserves) the analysis of interaction among variables leads to the appropriate interpretation that direct controls can focus on manipulation and reduction of welfare payments, thus forcing current recipients back to look for work within the existing economic system. In other words, their solution to unemployment is separated from the apparent causes. What is needed are mechanisms to get men to go to work and this requires greater societal control, or at least a modification in the control mechanisms to increase the penalties for not seeking and getting work.

The second remedial proposal that emerged from our analysis contains the majority of managers. The general tactics endorsed rested on ideas about economic health and maintenance of full-employment policies which may be encouraged through employment programs, grants, and publically sponsored indus-

²Sonquist, John A. and James N. Morgan, *The Detection of Interaction Effects: A Report on a Computer Program for the Selection of Optimal Combinations of Explanatory Variables*. (Ann Arbor, The University of Michigan, Institute for Social Research, Monograph no. 35, 1964).

trial inducements. This is, in other words, a variant of the ideology of a healthy economy, of public supply of economic inducements, so as to provide for more jobs. Insofar as the economy is kept intact, some beliefs in equal economic opportunities is given legitimation thereby allowing them to view the man without work as a personal failure. They encounter no dissonant expectation, therefore, in the belief that a good economy makes unemployment an individual problem. Moreover, this rationalization is made even more credible among them by the impact of "Protestantism" as an interactive variable. Equating wealth with virtue and poverty with sin is a predominately middle-class notion; the contemporary racism implies that both social status and self-esteem should be based on occupational success.

Our analysis and interpretation of AID findings leads to the conclusion that we are observing two economic *status quo* interpretations. The first branch included the bulk of managers who indicate things are beyond control now, but regard any solution to unemployment from a social policy point of view as even more damaging to them. The solution comes from control and economic inducement or punishment fits their rationale.

The second group, also expressing "own fault," would primarily make more jobs. Although they would permit a restructuring of the job market in order to create enough work, thus, removing the problem because all could work, they reject a redistribution of social and economic resources through the community since control of failure or economic misfortune is maintained by manipulation of the job market.

Neither branch in the analysis shows any great tolerance for solutions that involve institutional adjustments between economy and society, or requires a reassessment of work and human values in the social order. These are "economic" men, and being economically oriented, they do not reflect about themselves in terms of social change and human value but through the preserving of business and through it, themselves. Both hold that the effort to make the world over is absurd, to rephrase Sumner's classic title. Both branches of the AID reflect attitudes toward melioration which do not stand for increased public investment in social rights. Many acknowledge the private morality of charitable help for the poor, but believe it is bad economics to support funding of education, health, pollution control, training, or welfare. This fits an interpretation by Sutton (Sutton, et al. 1956). They write that according to the "Business Creed," "It would aggravate inflation, weaken the dollar, stunt economic growth, and in the long run kill the goose that lays the golden eggs."

B. Active Unionists

The majority (72 percent) of unionists reported that unemployment was beyond any one man's immediate control. Also 62 percent of the union members imply that "social" or "environmental" conditions tell why men found themselves in poverty, while only 38 percent say people are poor because they are failures or have some inherent impairment that ensures social inadequacy. Those proposing social "causes" of poverty regarding unemployment as largely extrinsic to a person's talents or motives, that is, as a matter of social factors and constraints.

The interaction analysis showed that even those unionists who hold the poor personally responsible or accountable for failures, reflect some ideological influence from union or from their working-class background when it comes to the issue of unemployment. In other words, they separate poverty and unemploy-

ment. Though they endorse social reasons for unemployment less often than other activists who see even poverty as personally uncontrollable, almost three in five believe job unemployment is outside a man's hands, not a matter of innate personal inadequacy which is imputed to the poor. Analysis of the interaction suggests that among them, there is something inherently more base or morally detrimental to being poor than to being unemployed. One reason for this viewpoint may be that the relative economic or occupational successes achieved by union members places them in the main stream of economic life where family and other concerns occupy their time. Poverty and the poor are out of their jurisdiction. And further, as Barkin and Blum (Barkin and Blum, 1963) have shown, the major problems facing trade unions are connected with technological change, automation, and subsequent unemployment. Poverty is thereby out of their jurisdiction, and an entirely different problem.

Four patterns were generated by the interaction between major variables. Two interaction patterns resulted among those expressing social conditions explain the poor. In the first branch, or uppermost pattern, some do view the union as a private voluntary association for dealing with the handling personal individual crisis. In the second pattern, unemployment seems to be dealt with either by strict adherence to classic union ideology that endorsed jurisdiction and job control or by personal inducement (reward those who will work!) These unionists show a desire to up-keep a status quo by inducing men to work, or use jurisdictional controls and established union organization as a means to hold on to control of the job market.

The remaining two interactive patterns, those established by endorsing a belief in personal causes for the poor, again exhibit some interesting views on control. Since these unionists most favor using some kind of public aid, the analysis of interaction shows the state government is perceived as the appropriate agent responsible for welfare adjustment. Public intervention in unemployment seems contradictory, particularly since unions are job control oriented, until one realizes that unions frequently lack viable democratic control and members come to favor a third party's intervention to protect worker rights. The last pattern also reveals jurisdictional job control representative of union ideology.

These patterns are striking because they separate poverty and unemployment as social problems for the active unionists. The unionists are less economically and social conservative and thus more apt to cite social grounds for poverty. This is not hard to understand because the issue of unemployment and its solution is a reality in the lives of the union activist.

In summary, an analysis of the interaction between the study variables leads to an interpretation that managers typically opt for economic solution by making more jobs, by public support of private profit through a guaranteed and sound economy, but with subsequent endorsement for the status quo of the economic system, and location of economic failure strictly fixed in individual failure; unionists seem to normally stress jurisdiction and job market control or a job-conscious personality approach. Therefore, redistribution of resources and deepened concern for major social and value changes is not an issue for either group, though the potential for it does exist within certain sectors of active unionists. Few of them endorse such wider activism though; the potential gets exhausted through public aid as a means for control of the job market. Managers also endorse public aid but only in so far as it induces men to work or produce an economy health, a "new dealism" approach. Those who are helped by public

aid are, then, an economic means to business; and the state is obliged to support economic interests in the system, for a good economy produces the taxes through which maintenance of government is guaranteed. So goes the interpretation between the data and rationale that assembles it.

Discussion

An examination of programs for re-employment and the attack on recalcitrant poverty shows a controversy between two camps of economic planners that have shown influence on the direction of recent social reforms. The proponents tend either to view adaptation structurally or to treat the system in its total aggregate.

The following presents attributes of main policy strategies which are the basis for program implementation or assessment.

AGGREGATE DEMAND	STRUCTURALIST
<i>Inducement:</i>	<i>Inducement:</i>
<ol style="list-style-type: none"> 1. Increase aggregate demand through general fiscal and monetary policy. 2. Involves all institutions in an attempt to stimulate the economy. 3. Provides forces which will result in expanding the number of job openings. 	<ol style="list-style-type: none"> 1. Decrease unemployment by bringing certain of the unemployed's, characteristics, such as occupational skills levels or occupational and geographic mobility patterns in conscience with the structures of labor market demands.
<i>Responsibility:</i>	<i>Responsibility:</i>
<ol style="list-style-type: none"> 1. Diffused throughout the social system. 2. System planning approach would involve legislative action on the federal and/or state level. 	<ol style="list-style-type: none"> 1. Private support but public responsibility. 2. Regional and local approach. 3. The question of commitment of those with resources to help retrain the unemployed as basic here as is sponsoring organizations.

The key to understanding the structural problem is its emphasis on the mismatching of specific labor skill demands and supplies where there is (1) limited transferability of skills and (2) limited substitutability among skills. Thus no structural problem exists when the labor force can itself adapt to new demands or situations, particularly those situations involving technological development. When skills are not viable in relation to demands, structural unemployment can exist, no matter what the level of demand.

The total aggregate strategy centers on levels of employment or number of job openings where total expenditures in the economy—total demand for goods and services—are not sufficient to generate an adequate total number of jobs. Both positions are used in economic policy decisions and consequentially have direct bearing upon social adjustment and planned change, as the structuralists want to refit the unemployed with usable skills and the aggregate demand theorists favor general economic stimulation through fiscal measures to speed the growth of total demand and thereby create new job opportunities.

In practice, planners and agents have normally had to consider the inter-

relatedness of both perspectives, and some have argued that the two are not simple complementary, but are mutually reinforcing. On the other hand, they say, training and other programs facilitating labor mobility eases and speeds processes by which demands stimulating increases in output are translated into increases in employment. On the other hand, given that structural maladjustments tend to flourish in slack markets, a vigorous expansion in demands helps cut structural problems down to size.

Furthermore, planners and action-oriented specialists feel pressed to bring personal experiences and collective values embodied in particular labor force populations under study to find out what events and resources are directly associated with particular problems. These practical considerations bring men back into theory; human interest and ideologies are real influences on activity which may operate sometimes to restrict, at other times to support, planned resolution.

Economic Ideologies of Local Managers and Active Unionists

The interaction analysis (AID) study suggests certain constraints upon any implementation of economic policies of the sort that was described. Both unionists and managers are interested in an expanded labor market. The managers view on unemployment is nearly exhausted by economic variables, and their interests focus on the supply of selectively skilled or employable individuals. The greater the supply of such labor, the greater the ability to control relevant criteria in their hiring practices. On the whole, this insures relatively low labor cost with limited demand on them for any special type of training. Since business is generally aided by economic stimulation, they are not disinclined toward policies based on aggregate demand inducement. The managers' attitudes about employment are explained by economic variables in this research; their attachment to economic incentives will be a factor in any program.

Unionists also favor expanded markets, but do so in terms of increased actual jobs. They normally want little competition for existing jobs. Unionists favor real increases in the number of jobs and favor, in this sense, aggregate demand. However, a concern with the unemployed also promotes realigning discrepancies between skills required for employability and development of new skills, or upgraded skills adaptive to technological innovations. Thus, they also favor training.

Yet, whether the responsibility for economic inducements is attributed to public or private sectors does not really seem very relevant to managers and unionists when it comes down to solving problems of local labor and unemployment. Only the federal government can marshal and allocate enough resources to fund major programs. Geographic factors operate, however, as the base of regional unemployment; these limits on economic power mean it is hardly possible for regional or local areas to be expected to support programs on their own already stretched economies.

Implications For Current Action Programs-Sailing Along on the Status Quo:

In this context it is possible to understand how a regionally organized program involving OJT (On-the-Job Training) can be amenable to some businessmen and to unionists, too. Under on-the-job-training programs "structuralist" goals can be achieved through public sector programs of the re-employed workers in

jobs where training is supplied by the businessmen. Business is subsidized with public funds for creating or filling jobs and training the individual.

Among unionists, the issue turns on how their several points of view can be brought to practical consensus. After all, evidence suggests that any or all patterns may be functioning among activists in some local areas. The unionists separate poverty and unemployment; they exhibit an economic class attitude endorsed by the union hierarchy and patented by the union intellectuals' ideologies. Locally among the rank-and-file, data shows that support for both public or private responsibility does exist. Some uphold the union organization in order to maintain balance between jobs and automation; others support increased jobs with reduced welfare.

Thus, data have shown that in the region, and probably in specific locales, there is support for programs aimed at control of labor through public inducements as a measure to increase union control of automation and of job jurisdiction. Both positions are confined within the existing social status quo and contain few elements conducive to radical restructuring of the economy or social values.

Some attempts have been made to organize programs within the Manpower Development Training Act. They seem likely to succeed where inducements to the system are supported by managers, and when the unionists are interested in active programmatic support. As an example, the AFL-CIO Appalachian Council, a co-operative effort to assist in Appalachian development, is currently involved in "Operation Manpower." This is a program which undertakes manpower development through a co-ordinated approach using labor, government, and industrial resources to reach its goal of "unearthing and understanding problems of the region, developing plans for their solution, and stimulating or undertaking specific projects or action programs for their elimination."

The most interesting aspect of this program is that the regional union federation is a kind of middle-man between local management and federal government funding agencies. The eleven state union federation contracts with local businesses and then is itself subsidized by the Department of Labor and HEW for reimbursement of training costs in five areas: (a) OJT (b) job related training, (c) Basic Education (d) vocational training, and (e) pre-apprentice training.

This particular approach seems to work with the existing system and is in effect a compromise program mentioned above in the discussion of management. Further, it involves the active unionists at the regional and local levels in a program of recruitment for both job corps and training positions in relation to the state employment services and the desires of the hiring firms. This on-going program has achieved quite decent success as reported in the *Operation Manpower Report* series and represents a mutually beneficial program endorsed by labor and management alike.

Literature Cited

1. Barkin, S., and A. Blum. 1963. "Is There a Crisis in the American Trade Union Movement? The Trade Unionists' Views." *The Annals of the American Academy of Political and Social Science*, November.
2. Dalton, M. 1959. *Men Who Manage*. John Wiley and Sons, Inc., New York.
3. Gallup, G. 1961. Gallup Poll Report, American Institute of Public Opinion, Spring.
4. Gilpatrick, E. G. 1966. *Structural Unemployment and Aggregate Demand*. Johns Hopkins Press.
5. MacDonald, A. P. 1970. "Attitudes Toward the Poor That Militate Effective Up-

- grading," Office of Research and Development, Monograph Series Report, Appalachian Center, WVU.
6. Miller, R. W., and F. H. Zeller. 1968. *Manpower Development in Appalachia*. F. A. Praeger, New York.
 7. Peck, S. M. 1963. *The Rank-and-File Leader*. College and University Press, New Haven, Connecticut.
 8. Sayles, L. R., and B. Strauss. 1953. *The Local Union*. Harper and Brothers, New York.
 9. Schneider, E. V. 1969. *Industrial Sociology*. 2nd ed., McGraw-Hill, Inc., New York.
 10. Sonquist, J. A., and J. N. Morgan. 1964. *The Detection of Interaction Effects: A Report on a Computer Program for the Selection of Optimal Combinations of Explanatory Variables*. The University of Michigan Institute for Social Research, Ann Arbor, Monograph no. 35.
 11. Sutton, Harris, Kaysen, and Tobin. 1956. *The American Business Creed*. Harvard University Press, Cambridge, Massachusetts.

