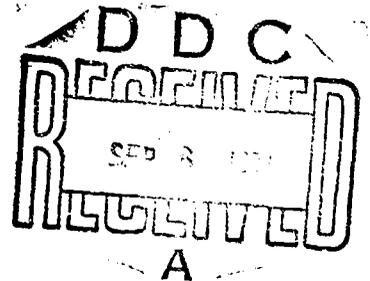




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FRANK J. SEILER RESEARCH LABORATORY

ANNUAL
DESCRIPTIVE
BROCHURE



1 JULY 1971



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AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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Frank J. Seiler Research Laboratory

FOREWORD

The Frank J. Seiler Research Laboratory was established at the United States Air Force Academy with a full time staff to conduct research in chemistry, applied mathematics and aerospace mechanics, to provide a means for supporting faculty research in those areas of interest to the United States Air Force, and to foster and encourage scientific research among cadets.

Colonel Frank J. Seiler, for whom the laboratory is named, retired from the Air Force in 1961 after more than twenty years of active duty. He is remembered for his devotion to increasing the stature of in-house Air Force laboratories and improving the career opportunities for young officer-scientists. He was the second commander of the Office of Air Research, later renamed the Office of Aerospace Research. Upon retirement in 1961, he became research coordinator for the University of Washington. He passed away suddenly in October 1962.

I hope this booklet will help you to become better acquainted with this AFSC Basic Research laboratory, especially our people and their work. Our activity meshes closely with the current academic program at the USAF Academy, but we also continually seek new ways to relate our research to future capabilities for the Air Force. Toward this end our scientists work closely with members of many governmental, academic, and industrial institutions. If you wish additional information on the laboratory or its research, please contact me or a member of the research staff.


MILTON D. SPRINKEL, Colonel, USAF
Commander

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Group One Key Words and Phrases Organic Synthesis Organometallic Metallocenes Organo-phosphorus chemistry Carborines Carbometallic-boranes Metallocene ladder polymers						
Group Two Key Words and Phrases Nitroaliphatics Fluoronitroaliphatics Energetic binders Plasticizers						
Group Three Key Words and Phrases Aluminum Anodes Molten Salt electrolytes Aluminum chloride electrolytes Sodium chloride electrolytes Formation cells Concentration cells Fuel cells High energy density batteries						
Group Four Key Words and Phrases Imperfect Information Differential Games Sub-optimal games						
Group Five Key Words and Phrases Adaptive linear discrete-time estimation Time-varying optimal estimate						
Group Six Key Words and Phrases Optimal entry guidance Non-linear bounded state problems Non-linear control systems Non-linear estimation filters Non-linear recursive estimation theory						
Group Seven Key Words and Phrases Radiation gas dynamics Magnetic annular shock tube Pulsed plasma accelerator Electric current shock wave in non-conducting gases Holograms of gas flows						
Group Eight Key Words and Phrases Ram-wing ground effect vehicle						
Group Nine Key Words and Phrases Slender body flow theory Delta-wing-canard configuration Shock-wave shaping through radiative transfer						

Frank J. Seiler Research Laboratory (AFSC)
USAF Academy

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The Frank J. Seiler Research Laboratory (AFSC)
United States Air Force Academy, Colorado 80840

INTRODUCTION

Mission

The Frank J. Seiler Research Laboratory is assigned the mission of conducting research in those areas of aerospace mechanics, applied mathematics and chemistry which offer the greatest potential for new knowledge essential to the continued superiority of the Air Force's operational capability; and fostering, encouraging, and supporting related research by USAF Academy faculty and cadets.

Special Responsibilities and Instructions

- a. Maintaining liaison with Air Force Research and Development and operational elements to identify research needs.
- b. Providing liaison between the Air Force and the scientific community in matters of potential Air Force interest involving aerospace mechanics, applied mathematics, and chemistry.
- c. Assuring the effective dissemination of research results for the advancement of future aerospace technology, weapons, and equipment; and providing scientific advice and consultation to all segments of the Air Force requiring knowledge and interpretation of the results of research in aerospace mechanics, applied mathematics, and chemistry.
- d. Functioning as AFSC focal point for all USAF Academy research proposed for sponsorship by AFSC Basic Research Laboratories and elements.
- e. Maintaining in-house laboratory operations of superior quality for the conduct of assigned research responsibilities, thus providing Air Force competence in aerospace mechanics, applied mathematics, and chemistry.
- f. Promoting, fostering, and encouraging an awareness and interest by the United States Air Force Academy faculty and cadets of the importance of scientific research in the Air Force; providing them with an opportunity for direct participation in aerospace mechanics, applied mathematics, and chemistry research; and coordinating the Summer Laboratory Program for faculty and selected cadets of the USAF Academy.

History

The development of the USAF Academy from legislative approval in April 1954 to graduation of its first class in June 1959 was a task of considerable magnitude.

With academic progress and a faculty with increasing numbers of doctoral degrees came the inevitable pressure to support research for both faculty and cadets. Since the product of faculty research could be of considerable benefit to the Air Force if funded and oriented appropriately, and since cadet research experience would help to produce officers who were qualified and interested in careers in research and development, the Air Force Systems Command and the Office of Aerospace Research were approached for assistance and advice with regard to the establishment of a research activity at the USAF Academy. A proposal made by the Office of Aerospace Research in February 1962 to establish a small in-house laboratory at the Academy was approved by the Air Force. The laboratory was formally established with the assignment of two officers on 1 September 1962.

Even before the final establishment of the laboratory, specifications were being prepared for a computer to allow digital computing to be made a required part of the Air Force Academy curriculum, to provide the means for teaching advanced science and engineering courses, and to support research in all departments. The availability of computational and information processing capabilities in the form of the digital computer is essential to the basic research of the Seiler Research Laboratory, as well as an active and imaginative research program at the Air Force Academy. Knowledge and training for future Air Force officers in the use of the digital computer was recognized as essential to the long term goals of the Air Force.

In the Office of Aerospace Research proposal for the establishment of a research laboratory, it was stated that the computer would be procured and operated by the laboratory with a co-use agreement with the USAF Academy whereby the laboratory would furnish adequate computer time to the USAF Academy for the accomplishment of its faculty research and for cadet computer courses and other courses where a computer is needed. This support could be considered as analogous to Federal grants to civilian universities.

The establishment of a research and educational computer system based upon this rationale and with these purposes was proposed to Headquarters USAF in a Data Automation Proposal dated 1 November 1962. The concept was approved and acquisition authority was granted on 20 February 1963. A Burroughs B5000 computer became operational in June 1964. In January 1965, the computer was modified to the B5500 configuration. Twenty remote consoles throughout the USAF Academy were added during 1969. In 1968, the computer facility provided support and services for 34 Academy courses; 8 of which were in computer science. Enrollment in computer science courses reached 1100 cadets in 1967. Approximately 1900 cadets were using the computer in other scientific and engineering courses. In addition, 85 research projects by Seiler Research officers, Academy faculty, and cadets were furnished computational support. The level of activities continued to grow during the 1969-70 school year when the computer facility provided support for 71 Academy courses, 9 of which were in computer science. Enrollment in computer science courses reached a new high in 1969 with 1400 cadets enrolled. Another 2400 cadets were using the computer in

other scientific and engineering courses. There were 176 research projects by Seiler Research officers, Academy faculty, and cadets supported by the computer during the 1969-70 school year.

With the continued expansion of the Cadet Wing the USAF Academy increased its share of use of the computer to 90% during the 1970-71 school year. The capacity of the computer was increased during December 1970 by 50% by means of an augmentation of input-output equipment and the substitution of larger faster high speed internal memory devices. The new configuration caused the projected cost for the 1971-72 school year to exceed the limitation placed upon the laboratory by its parent command. Accordingly the computer was transferred to the USAF Academy on 1 July 1971.

The construction of the Frank J. Seiler Research Laboratory large multi-purpose low density shock tube was completed in September 1965 and it was formally dedicated in October 1965. It is physically located in the Aeronautics Laboratory at the USAF Academy and is gasdynamically similar to the low density shock tube in place at the California Institute of Technology. The tube is 84 feet long with a 17-inch inside diameter. The test-section initial pressure can be varied from $1/4\mu$ Hg up to atmospheric pressure. Any non-corrosive gas or combination of bottles non-corrosive gases can be used in either the driver or test sections. Mach numbers ranging between 2 and 10 have been attained in argon at various initial pressures. A desired Mach number can be repeatedly attained to within 0.5%. The tube has excellent integrity as a vacuum vessel, with a leak rate of less than $.01\mu$ Hg/hour.

The instrument is an extremely versatile device for studies in real gas-dynamics (chemical kinetics, shock-associated phenomena, etc.). Primary interest lies in its use for re-entry gasdynamics involving shock wave structure and in the formation and attenuation of shock waves. One of its values to date has been its use as an instructive tool and research instrument for Air Force Academy cadets. The tube was financed by the Frank J. Seiler Research Laboratory and designed by and built under the supervision of Capt Charles F. Stebbins of the Frank J. Seiler Research Laboratory and Maj Douglas S. Johnson of the USAF Academy. Many of the engineering problems that arose in the design and construction of the shock tube were solved by cadets as cadet independent research projects. Ten cadets participated in the design, checkout, and construction of the tube.

The FJSRL has conducted research in applied mathematics with an emphasis on system optimization and control. Here the prime objectives are the development of mathematical models of physical systems and the development of the mathematical and computational procedures for the optimization and control of such systems. It includes studies of the effects of randomness in systems such as might be encountered by aircraft or missiles subject to random gusts or disturbances, and in the detection of signals in the presence of noise. It includes studies in nonlinear and adaptive control of systems with the aim of designing autopilots and control systems for advanced aerospace vehicles. It emphasizes computational procedures in optimization such as those that might be required for the optimum steering or guidance of aerospace vehicles.

With the increasing interest and capability of the FJSRL scientists in the Guidance and Control area arrangements were made with the USAF Academy faculty

for the Seiler Laboratory to take over the operation of the Inertial Guidance Laboratory on 1 July 1971. FJSRL proposes to respond to the technology requirements of the Air Force Systems Command Laboratories, the Electronic Systems Division, and the Space and Missile Systems Organization, in a timely manner, with experimental verifications of the new degrees of precision sought by these organizations. Major test equipment, including a real time signal analyzer, expanded data acquisition and display equipment, laboratory environment sensors and controls, test-specimen electronics, and a contingency power source are being procured early in this FY.

The Chemistry Division, FJSRL, has two laboratories which became operational in March 1964. These are adjacent to each other and consist of a synthesis laboratory and an instrument laboratory. The synthesis laboratory is a conventional preparative laboratory with working spaces for six chemists. Most of the specialized chemical instruments are maintained in a separate instrument laboratory which is well equipped for the activities of FJSRL. Access is also available to the instruments of the USAF Academy Department of Chemistry in a nearby laboratory. During 1967 FJSRL completed furnishing the instrument laboratory, and constructed a new chemical storage facility. New office facilities and a conference room were added in the early part of 1969.

Research in Chemistry, while very fundamental scientifically, is directed at solving critical Air Force problems. The areas of materials, explosive compounds and electrical power sources provide possibilities for operational improvement through research in chemistry. For this reason the Directorate of Chemical Sciences has concentrated its efforts as follows: (1) studying organometallic compounds as precursors to unique polymers for materials applications, (2) studying nitroaliphatic and fluoronitroaliphatic compounds for use as energetic binders and plasticizers in explosives, and (3) studying the chemistry of aluminum anodes in fused salt electrolytes for application in fuel cells and batteries.

While plans for the Frank J. Seiler Research Laboratory were made in an austere environment, it was realized that the full time scientific staff had to be large enough to provide a catalytic or "critical mass" effect. The manpower authorization was set at 37 people, until November 1967 when it was increased to 39 people. It is now set at 31, 20 are Research scientists and the remaining are supporting and staff positions. The annual laboratory budget is approximately \$500,000.

The military and civilian scientist posts are filled by highly qualified personnel all of whom have advanced scientific degrees mostly at the doctoral level. All of the scientific staff have been given faculty status as research associates, or in one of the professorial ranks.

Some members of the military scientific staff teach cadet courses, and this activity is encouraged to the extent that it relieves faculty members to do research and does not detract from research efforts of Seiler personnel. Teaching is encouraged because teaching is as desirable for a good researcher as research is for a good teacher. The policy has resulted in good rapport between Air Force Academy faculty and the FJSRL staff and is partially responsible for attracting highly motivated cadets to participate in FJSRL research projects. One scientist space in the

Directorate of Chemical Sciences is reserved for USAF Academy Chemistry Department faculty members for one year tours.

FJSRL resources may be used to fund faculty research in areas of direct interest to USAF. Faculty members may propose research projects for FJSRL support in a manner similar to the way that faculty members of civilian schools propose research projects to the Office of Scientific Research. However support to USAF Academy faculty by FJSRL is limited to equipment, supplies, and travel, and does not include salaries or indirect cost. This kind of support is provided to a number of faculty members each year. In special cases where interests of the faculty are closely allied to interests of this laboratory, it is possible to exchange individuals between the laboratory and faculty.

Another activity of FJSRL is a program for assigning faculty officers and cadets to basic research installations during the summer recess as working researchers for periods of approximately six weeks. Arrangements are made well in advance so that time spent at the laboratories is as profitable as possible to all concerned. Ten to fifteen officers and cadets are assigned to this program each summer. Basic Research laboratories report that the benefits of this program are substantial to all agencies and individuals.

Plans for this laboratory envision a modest growth in effort and a budget with cost-of-living increases and occasional special funding for updating equipment to provide a stable, modern, and fertile environment in which to perform research. The emphasis is on quality and will remain so. It was hypothesized in 1962 that the laboratory could be manned primarily with officer scientists, could produce worthwhile research, could secure cadet participation, and could improve the opportunity for research among the faculty. In its early years of operation the laboratory has succeeded on all counts. By 1972 the USAF Academy will have completed its expansion from 2500 to 4400 cadets with a corresponding larger faculty. The catalysis provided by the small full time research staff of the Frank J. Seiler Research Laboratory will continue to work effectively with the larger faculty just as it does now.

AFSC BASIC RESEARCH LABORATORIES/USAF ACADEMY

SUMMER RESEARCH

The AFSC Basic Research Laboratories/USAF Academy Summer Research Program constitutes a period of temporary duty of a number of faculty members and cadets of the USAF Academy with AFSC Basic Research Laboratories and provides benefits to both the USAF Academy and units visited. Faculty members have the opportunity of acquainting themselves and assisting with current programs of Air Force research in their fields of interest. At the same time the laboratories benefit from the work and fresh ideas of the faculty member during the six weeks he spends contributing to some problem of mutual interest to the unit visited and himself. Indeed in a number of instances an officer has continued work on the same research after he returned to the USAF Academy and directed cadets on smaller segments of the research. The program therefore has provided some important benefits to the faculty in their academic specialties and to the cadet academic program itself.

The AFSC Basic Research Laboratories/USAF Academy Summer TDY Program for cadets offers similar mutual benefits. The select group of cadets learn the importance of combining the knowledge they have gained in different courses in order to solve actual problems of Air Force research, and they in turn bring their energies and intense desire for accomplishment to bear on current USAF research supervised by senior AF scientists.

Table I

Summary

Year	Officers	Cadets
1963	6	0
1964	7	4
1965	12	12
1966	6	5
1967	3	17
1968	3	19
1969	3	8
1970	1	6
TOTAL	41	71

SUMMER RESEARCH PROGRAM

Officer Participants

Table II

Year	Officer	Laboratory	Field
1963	Maj Howard M. Estes Capt George B. Berke Maj Robert P. Reid Capt John A. Wesner 1Lt Harry L. Morrison Lt John Francis*	ORA ORA AFCRL AFCRL AFCRL ARL	Systems Analysis Research Reporting Research Reporting Electronics Physics Hypersonics
1964	Maj Carl F. Davis Maj Phillip J. Erdle Capt Carter M. Glass Capt Alfred J. Hallisey Capt Kenneth H. Kronlund Capt Philip L. Cooper Capt Kenneth E. Brant	AFCRL AFCRL AFCRL AFCRL AFCRL AFOSR FJSRL	Electronics Mechanics Microwave Physics Optical Physics Solid State Physics Chemistry Computer Science
1965	Lt Col George W. Brock Maj Raymond H. Kelley Maj William A. Kirkman Capt John C. Balogh Capt Robert W. Burton Capt Vincent D. Galbi Capt Stanley F. Choate Capt Albert H. Neubauer, Jr. Capt Joseph W. O'Neil Capt John F. Ahearne Maj Richard L. Eisenman 1Lt Stuart F. Spicker	ARL ARL AFCRL PSU (FJSRL) AFCRL AFCRL AFCRL AFCRL AFCRL AFCRL Yale (FJSRL) Hq USAF(ARAC) VAH (FJSRL)	Solid State Physics Nuclear Physics Numerical Analysis Solid State Physics Microwave Physics Chemical Physics Electronics Structural Dynamics Lunar Physics Nuclear Physics Operations Analysis Psychology
1966	Maj George W. Macpherson Maj Donald A. Slezak Capt Larry H. Buss Capt Carter M. Glass Capt John P. Kershaw Capt John V. Schafer, Jr.	AFCRL AFCRL AFCRL AFCRL AFCRL ARL	Network Theory Electronics Data Analysis Microwave Physics Crystal Growth Hypersonics
1967	Lt Col Paul L. Briand, Jr. Capt Richard R. Price Lt Theodore L. Willke**	AFCRL ARL ARL	Linguistic Analysis Fluid Dynamics Applied Mathematics
1968	Maj Albert E. Preyss Maj Richard E. Willes Lt B. C. Burnett	ADWC (FJSRL) ADWE (FJSRL) AFCRL	Systems Research Systems Research Space Physics

* 1963 USAF Academy Graduate

**1967 USAF Academy Graduate

Table II (continued)

1969	Maj Richard B. Willes Capt Carl A. Forbrich Jr. Lt Joseph E. Justin*	AKL AFCRL FJSRL	Aeronautics Gas Kinetics Systems Simulation
1970	Maj Sidney B. Franklin	AFCRL	Microwave Physics

* 1969 USAF Academy Graduate

SUMMER RESEARCH PROGRAM

Cadet Participants

Table III

Year	Cadet	Laboratory	Field
1964	Gregory H. Canavan	ARL	Mathematical Physics
	Patrick J. McDaniel	ARL	Astrodynamics
	William E. McDermott	ARL	Chemistry
	Warren H. Sierer	ORA	Numerical Analysis
1965	David J. Galas	AFCRL	Meteors
	Ronald J. Grabe	AFCRL	Cloud Physics
	Alan B. Cheeseman	ARL	Plasma Physics
	John C. Conrad, Jr.	ARL	Astrodynamics
	Llew S. Dougherty	ARL	Hypersonics
	Raymond F. Milberg	ARL	Solid State Physics
	Hans J. Mueh	ARL	Biophysics
	William B. Rankin	ARL	Solid State Physics
	Harry P. Wetzler	ARL	Nuclear Engineering
	Michael C. Wirth	ARL	Applied Mathematics
	Daniel I. Twomey	ORA	System Analysis
Michael O. Wheeler	ORA	Applied Mathematics	
1966	Joseph E. Caudle	AFCRL	Solar Physics
	Allen M. Hunter, II	AFCRL	Ionospheric Physics
	John H. Pletcher, Jr.	ARL	Numerical Analysis
	John P. Retelle, Jr.	ARL	Hypersonics
	Michael C. Wirth	ARL	Solid State Physics
1967	Walter W. Adams	ARL	Solid State Physics
	Martin S.F. Eggert	ARL	Supersonic Compressors
	Thomas M. Jones	ARL	Supersonic Combustion
	Ronald L. Kerchner	ARL	Fluid Dynamics
	Michael G. McCalley	ARL	Plasma Physics
	David R. Alexander	AFCRL	Electronics
	Donald J. Caughlin, Jr.	AFCRL	Lasers
	Charles J. Corley	AFCRL	Computers/Electronics
	James M. Cupello	AFCRL	Laser Crystals
	James E. Neu	AFCRL	Plasma Physics
	Donald E. Schenk	AFCRL	Ionospheric Propagation
	Terry R. Zubrod	AFCRL	Radiometry
	William D. Eckert	AFOSR	Science Management
	John C. Frost	AFOSR	Science Management
Joseph F. Drupa	UCLA (AFOSR)	Chemistry	
Ronald O. Rasor	UCLA (AFOSR)	Chemistry	
Michael J. Wanger	UCLA (AFOSR)	Chemistry	
1968	Steven H. Edelman	ARL	Fluid Dynamics
	Terry A. Hammond	ARL	Applied Mathematics
	Joseph Hasek	ARL	Applied Mathematics
	Edward C. Land, II	ARL	Applied Mathematics
	Robert C. Rue	ARL	Applied Mathematics

Table III (continued)

	Donald A. Zimmerman Charles V. Duncan, III James C. Campbell David J. Nielsen Goyette, John A. Stephen C. Gillette Thomas L. Allen Richard B. Doyle Glenn H. Schlabs John H. Evans, III Richard F. Rivers Michael J. Beezley Paul W. Farrell, II Gregory M. Kronberg	ARL ARL AFCRL AFCRL AFCRL ORA ORA ORA ORA ORA AFOSR AFOSR UCLA (AFOSR) UCLA (AFOSR) UCLA (AFOSR)	Solid State Physics Plasma Physics Microwave Physics Micrometeorology Microwave Physics Systems Analysis Mission Analysis Mission Analysis Systems Analysis Research Management Research Management Chemistry Chemistry Chemistry
1969	Karl T. Hutchinson Thomas A. Menard Richard C. Murrow Vincent C. Puglisi David J. Radcliffe Paul Rossetti Richard B. Smith Richard E. Swanson	ARL AFCRL ARL AFCRL ORA ARL ORA AFCRL	Solid State Physics Solid State Physics Aeronautics Terrestrial Science Political Science Aeronautics International Affairs Fluid Dynamics
1970	Gary C. Burngrover Ronald Cassano John A. Blind Douglas A. Stoll Steven R. Bristow Braxton T. Gilmore	ARL ARL ARL ARL AFCRL AFCRL	Rarified Gas Flow Viscous Flow Fracture Mechanics Gamma-Ray Spectra Microwave Physics Microwave Physics

ACHIEVEMENTS

CHEMISTRY

The achievements of the Seiler Laboratory Chemistry Program in the form of sound basic research have been noteworthy since the Laboratory has been in existence. Basic research in chemistry is oriented to relate directly to Air Force needs. Programs are constantly reviewed in order to investigate new areas of chemistry with the greatest potential for Air Force use. Achievements in current areas of research are discussed below; however, achievements on past programs are indicated under publications in this brochure.

Electrochemistry: With the increasing dependence of Air Force systems on electrical and electronic devices, an increasingly acute need has developed for batteries and fuel cells which are characterized by large energies per unit weight and per unit volume. In an effort to satisfy this need, the Seiler research team is investigating the use of aluminum as an anode material in electrochemical cells having molten salt electrolytes. Aluminum was selected as a candidate material for several reasons foremost of which is the fact that its compounds are characterized by large negative heats of formation.

Most of the work to date has been conducted in melts consisting of mixtures of aluminum chloride and sodium chloride. In an effort to better understand the behavior of these melts, an extensive effort has been devoted to measuring the physical and electrochemical properties both of pure aluminum chloride and of melts containing this material. Using ultra-pure aluminum chloride, prepared by a method developed in the Seiler Laboratory, the vapor and liquid densities of this material have been determined over the entire liquid region, and a new value for the critical temperature has been obtained. In addition, preliminary measurements of the viscosity and surface tension of pure aluminum chloride have been completed.

A recently completed theoretical analysis has illuminated for the first time the structure of aluminum chloride/sodium chloride melts. The model indicates which ionic and molecular species are important in the melt, and explains the vapor pressure and electrochemical data published to date.

One of the most significant achievements by the electrochemistry group is the development of a concentration cell capable of voltages in the range from 0.40 to 0.56 volts. Two patent applications have been submitted based on certain aspects of this cell.

Another device developed by the group which seems to have promise is a rechargeable cell having a high current capability and an open circuit voltage of 2.5 volts. An invention disclosure detailing this cell has been submitted.

Two significant awards have been received by members of the electrochemistry group. For developing the concentration cell, Lt Col L. A. King and Maj D. W. Seegmiller have received the Air Force Research and Development Award. These two members of the electrochemistry group are Tenure Professors of Chemistry, assigned to the Department of Chemistry, USAF Academy. In addition, a paper submitted by Lt Col King Maj Seegmiller and Capt A. A.

Fannin has been selected as the winning paper in the Science Area to be presented at the Air Force Systems Command Science and Engineering Symposium in October 1971.

Organometallic Chemistry: The selection of this area of research was based on the Air Force's requirement for stable polymeric materials. The Air Force Materials Laboratory, through coupling activities, pointed out several areas where basic research is needed to help solve critical materials problems. The objective of this work was to synthesize new compounds which can be polymerized to form "ladder" polymers. One approach was directed toward preparing difunctional negative ions whose functional parts are connected to each other in two or more places by stable bridging groups. Dibridged ferrocenes serve as a precursor to the doubly-bridged biscyclopentadienide ions.

A series of dibridged ferrocenes ($[m][n]$ ferrocenophanes) have been synthesized where m and n are 3, 4, and 5. Compounds having the bridges both α and β to each other were obtained. These ferrocenophanes serve as intermediates for reductive cleavage to biscyclopentadienide ion. During FY71 investigations to study physical and chemical properties of the new compounds have been conducted as well as studying methods of reducing ferrocenes and substituted ferrocenes. A computer program for NMR spectra simulation has been used to interpretate the NMR spectra of a series of mono- and diacetyltrimethylene ferrocenes. The theoretical chemical shifts of various aromatic protons were calculated using the method of ApSimon and others for the treatment of the acetyl group. Since the measured chemical shift differences could not be explained from these anisotropic effects alone, a theory was formulated based on the perturbation of the non-bonded electronic orbitals of the iron by the carbonyl orbitals. This work is being written up for publication and will be presented at the National American Chemical Society meeting in the fall of 1971.

A mass spectral study of approximately 25 ferrocene derivatives has been completed which has yielded significant structural information on these new compounds. Two publications are being written and a paper is being presented at the National American Chemical Society meeting in the fall of 1971.

Nitroaliphatic Chemistry: The experimental work on the new research area of nitroaliphatic chemistry was begun in FY71. This work was requested by the Air Force Armament Laboratory. An efficient scale synthesis for an homologous series of explosives has been developed. The homologous series, trinitroethyl esters of straight chain carboxylic acids has been synthesized by the newly developed method. The procedure gives higher yields of purer product with shorter reaction times than methods which have been previously investigated for this type of chemical reaction. The procedure involves the mixing of reactants, trinitroethanol and the dicarboxylic acid, with an excess of trifluoroacetic anhydride at room temperature, and is workable either on the laboratory or pilot-plant scales.

The procedure cited above makes available, for the first time, a series of explosives with systematic variation of structural parameters for testing detonation phenomena. Three of the eight compounds synthesized by Seiler personnel have been selected for large scale production by the U.S. Naval Ordnance Station, Indian Head, Maryland. These compounds will be used by a number of other AEC and DOD laboratories for testing.

APPLIED MATHEMATICS

FJSRL research in the mathematical sciences is documented as Project 7904, entitled Optimization, Programming, and Control. This project was initiated in 1964 as a continuing Air Force in-house research project, having as its objectives: (a) to develop mathematical models of physical systems; (b) to provide mathematical and computational algorithms for optimizing or controlling such systems; (c) to develop techniques applicable to designing practical navigation, guidance, control, and communication systems; and (d) to provide a computational facility to support these investigations and the research and academic programs of the USAF Academy.

FJSRL research in mathematical modeling is typified by a study of the mechanism that causes human eye movements. The result, development of the most realistic model to date of the human eye-positioning mechanism, has generated worldwide interest; requests for copies of the technical papers have been received from over thirty American and foreign military and civilian neurological and medical institutes.

In the area of optimal control, an investigation of the attitude control of a spinning vehicle resulted in a highly-efficient computational procedure for deriving control laws that provide time-optimal re-orientation under varying conditions of spin rate, vehicle geometry, control magnitude, and thruster configuration.

A new algorithm to realize a truly-optimal non-linear estimator was successfully implemented on a general-purpose digital computer. Sub-optimal estimators now commonly derived from a Taylor-series expansion of the non-linear equations describing a system are frequently unreliable or unstable in many critical situations. This new scheme involves deriving the mathematical description of the filter directly from the non-linear system equations.

Research in adaptive control is exemplified by studies of the control of unstable mechanical systems, e.g., maintaining the balance of a steerable rocket vehicle during launch. A study of the effects of extreme flexibility on the control and controllability of a flexible boost vehicle showed that a control thruster of limited output could not only balance the vehicle, starting from sufficiently small initial conditions, but could also dampen motions due to an arbitrary number of the booster's bending modes. Investigation of a controller for a rigid booster whose mass-center location is unknown resulted in a new adaptive control technique that exploits the chatter motion of on-off controllers to give stability to such an unstable system. The research earned the investigator a 1966 USAF Research and Development Award.

FJSRL research in system optimization has included the development of computational procedures for vehicle trajectory optimization. The method of steepest descent was generalized so that it could be readily applied to multistage optimization problems, such as those which occur in the optimal operation of aircraft and missiles, and improved by the development of a more efficient computational procedure.

Aggressive effort has been made to apply knowledge and competency in optimization techniques to Air Force problems. A research project on tactical aircraft-missile engagements was undertaken as the result of a memorandum from DDR&E to SAFRD. Goals of the study were the quantitative description of maneuvers, the

development of new tactics, and the determination of quantitative measures of effectiveness of various parametric improvements in either missile or aircraft design. One investigation, an optimization study of aircraft-missile engagements, applied modern mathematical optimization techniques, including the mathematical method of steepest ascent, to digital computer models of realistic aircraft and missiles. The result was a methodology which enables determination of the best maneuver (one which generates the largest miss distance) for an aircraft to fly when attacked by a SAM. Results of this effort received an OAR Technical Achievement Award for 1968.

In subsequent research, the theory of differential games, the natural mathematical framework for treating optimal control problems involving competition such as aerial combat, has been extended to handle realistic problems in which competing dynamic systems are non-linear and one-player has a time delay in information about the state of his opponent's system. This result, a generalization of the Hamilton-Jacoby theory for full information differential games, earned the principal investigator an AF Scientific Achievement Award in 1970.

Notable results were obtained in FY71 in the following areas:

a. A numerical scheme to solve optimal control problems subject to state-variable inequality constraints has been developed. This scheme is a new approach which differs from other similar schemes by: (1) an initial trial solution which satisfies the nonlinear plant equations is not required; (2) specified boundary conditions are easily satisfied and are always satisfied from iteration to iteration; (3) the times on and off a constraint boundary are handled automatically and heuristic guesses in which direction the time shifts are required are not needed; and (4) intermediate solutions (although not yet optimal) are feasible solutions which are always an improvement over the previous iteration's solution. The scheme is applicable to analyses of high performance vehicles (such as entry vehicles or fighter aircraft) whose performance envelopes are constrained by structural, human, environmental, and/or control limitations and require the acknowledgment and inclusion of these boundaries in the analysis.

b. Early in FY71 a new program of applied mathematics research in inertial navigation, guidance, and control was initiated. This program's goals are the development and refinement of mathematical models and descriptions of phenomena, devices, and systems which affect and enable improved navigation, guidance, and control by inertial means. Some significant results have already been obtained:

(1) An analytical method has been described for transforming data from a single pair of orbiting satellites into a direct worldwide mapping of localized anomalies in the earth's gravitational potential. The data consists of on-board measurements of the relative velocity between the satellites. The relative velocity constitutes a measure of the difference in kinetic energy adjustments required by the individual satellites as they pass sequentially over an anomaly, and can be converted directly into the desired mapping. The method has sufficient sensitivity that localized gravitational anomalies small enough to go undetected by it would, for example, contribute less than 50 feet to an ICBM CEP.

(2) An analytical method has been devised for extracting, in seconds in the laboratory, the short-term performance parameters of inertial gyroscopes in the presence of a realistic (high-g) specific-force environment. This method uses for the first time a precision centrifuge with a counter-rotating platform as a quantitative test bed to provide deterministic specific-force inputs. Gyro output data are then analytically fitted to an assumed error model to provide a complete set of specific-force-sensitive drift coefficients after each five rotations of the centrifuge arm. This method can yield precision coefficients appropriate to an ICBM's high-g short-duration operation regime in seconds, rather than hours as now required, and without employing expensive aircraft and missile flight test programs. In addition, the method can reduce projected laboratory gyro-acceptance-test costs by 80%. This result earned for FJSRL the Air Force Systems Command Laboratory Outstanding Technical Achievement Award for December 1970.

FLUID MECHANICS

Research in the mechanics of fluids is documented as Project 7905, entitled Gas Dynamics. This project was established in 1964 as a continuing Air Force in-house research project, having as its objectives: (a) to develop and verify new theories of gas-dynamic phenomena important to high-speed high-altitude flight (such as the structure and behavior of shock waves in rarefied gases; radiation gas-dynamics; gaseous reactions and flow phenomena); and (b) to provide an experimental facility and instrumentation to support such research. The following results are typical of those obtained in recent years.

Classical theoretical studies of transverse ionizing magnetohydrodynamic (MHD) shock waves indicate that a shock wave tends to an ordinary shock wave for low plasma temperatures, and to an MHD shock wave (shock propagating into a hot gas) for high plasma temperatures, both cases uniquely describable by conservation equations alone. To provide experimental substantiation, measurements of the electric field of a plasma, E , the plasma magnetic field, B , and the shock velocity, u , were made in an inverse pinch device in low pressure hydrogen and combined with a state equation for equilibrium real-gas effects. Preliminary results indicated that the theoretical analyses were correct. Further, Ohm's law for the uniform plasma, $E = -u \times B$ was verified.

A theory describing a possible structure and physical model for a discontinuity separating two uniform non-conducting states in a gas has been developed. This theory permits the calculation of the current sheet strength for fixed upstream gas conditions (pressure, density and velocity) and varying applied magnetic and electric fields.

A simple model of true spectral behavior in radiative gas dynamics, applied to the characteristics calculation of the flow fields generated by slender hypervelocity vehicles, has revealed that surface pressures are largely insensitive to enhanced realism of the radiative interaction; hence, the effect of even strong radiation upon aerodynamics is small. Even though the radiative heating loads predicted by simple gray gases were significantly altered by refining the gaseous radiation, it was confirmed that heating loads were insensitive to the details of the non-grayness.

A related study has produced numerically-exact predictions of pointed-body flow-fields in absorbing/emitting gases. These are the first exact solutions

in two-dimensional radiative gas-dynamics which are unrestricted in Mach number, body shape, or generality of the radiative interaction. Comprehensive study of such solutions can lead to the most effective use of surface shape and emissive properties to alleviate radiative heating loads and to minimize wave-drag upon reentry vehicles. This result earned the investigator a USAF Scientific Achievement Award in 1970.

A one-dimensional theory of flight for the Ram-Wing, a high-speed ground-effect vehicle with a basic air-foil shape, was developed and experimentally verified. Models designed on the basis of the one-dimensional theory display extraordinary stability and achieve ground-clearance/span ratios on the order of 5% and lift/drag ratios greater than 30, far exceeding those possible by existing aircraft and ground-effect vehicles, while operating in the speed range of propeller-driven aircraft.

Significant results were achieved in FY71 in the following areas:

a. A method was developed for making theoretical predictions of the aerodynamic interaction of multiple lifting surfaces of arbitrary planform in the presence of leading edge separation. This research constitutes the first known comprehensive analysis of slender delta-wing and canard configurations. The approach can be applied to slender wing-flat combinations with or without gaps. This application has relevance to predicting low-speed aerodynamics of lifting reentry vehicles. Since slender wings are optimally loaded at low speeds and have small wave drag supersonically, delta-wing/canard configurations could be optimized using these results to obtain many of the advantages of variable geometry with considerably less mechanical complication.

b. A new multi-fluid model of electrical current sheets driven through non-conducting gas by a magnetic field has been developed and systematically investigated for a wide range of boundary conditions. Satisfactory agreement has been obtained with published magnetic annular shock tube experimental results. This is the first theory to predict current sheet speeds greater than the "snow plow" theory and less than the gas-ionizing shock wave theory. Since many experimental current sheets travel between these two speeds, the new model identifies an important multi-fluid mechanism of current propagation which may be useful in the design of electric propulsion systems for long-duration space missions, such as inspection satellites. An invention disclosure, describing an "Electromagnetic Gas Accelerator" which uses current sheets predicted by this theory, was submitted in November 1970. This device is potentially much more efficient than existing electric propulsion devices, because nearly all the electrical energy supplied is converted to directed energy (velocity) of the flow or to thermal (temperature) energy while almost none is consumed in ionizing the gas. A paper describing this result was selected for presentation at the 1971 Air Force Science and Engineering Symposium.

CURRENT ACTIVITIES

CHEMISTRY

The current work in Chemistry at the Frank J. Seiler Research Laboratory can be discussed most logically under four categories. These are:

- a. Electrochemistry
- b. Organometallic and Aromatic Heterocyclic Chemistry
- c. Nitroaliphatic Chemistry
- d. Faculty supported research

Electrochemistry: Current research by the electrochemistry groups is in two general areas: (1) determination of physical and electrochemical properties and (2) design and testing of prototype devices.

Having completed liquid and vapor density measurements for pure aluminum chloride, the group is now beginning the much more difficult task of making similar measurements for aluminum chloride/sodium chloride melts. The vapor pressure over the melt will also be measured.

Investigation of the electrochemical behavior of concentration cells is continuing; particular emphasis is being placed on cells in which one electrode compartment contains electrolyte with approximately 50-mole percent aluminum chloride; careful measurements should provide data that will permit refinement of the model for behavior of the melt.

Measurements of the viscosity and surface tension of pure aluminum chloride are continuing.

With regard to design and testing of prototype devices, current efforts are being focused on the concentration cell, the secondary cell, and a primary cell. The kinetics of electrode processes are being investigated, and methods for lowering the operating temperature of the cells are being sought.

Organometallic and Aromatic Heterocyclic Chemistry: The goal in this research area is to prepare organometallic and aromatic heterocyclic compounds which can be converted into "ladder" type polymers. Seiler research is being concentrated on synthesizing and characterizing new compounds which have potential for this purpose. This work is being closely coupled with the Air Force Materials Laboratory.

Emphasis has been placed on synthesizing ferrocenophanes, with varying number of carbon atoms in the bridging groups, which can possibly be converted into doubly-bridged dicyclopentadienide compounds via the corresponding tricyclic tetraenes. A significant number of new ferrocenophanes and the ferrocene derivatives have been synthesized and are currently being characterized by NMR, IR, UV, and mass spectrometric techniques. Investigations on the reductive cleavage of substituted ferrocenes by chemical and electrochemical means are being conducted. The reductive cleavage is required to convert the ferrocenophanes to the corresponding unsaturated tricyclic hydrocarbons. Thallium derivatives offer

promise of stabilizing the unsaturated reactive hydrocarbons. These hydrocarbons are sought as potential monomers for ladder polymer formation.

Recent coupling activities, with the Air Force Materials Laboratory, have indicated the need for increased basic research activities in the area of aromatic heterocycles for use in the synthesis of fused ring (ladder type) polyheterocyclic polymers. Since Seiler has qualified personnel and the needed equipment for this type research, a new program in this area is currently being planned and experimental work will begin in early FY72. In addition to fulfilling an Air Force need, the research in aromatic heterocyclic chemistry will broaden our research program and make it more attractive for both Air Force Academy faculty and cadets.

Nitroaliphatic Chemistry: The goal of this work is to study the chemical and physical properties of nitroaliphatic and fluoronitroaliphatic compounds and relate these properties to their explosives properties. This work should provide synthesis of new compounds which have a high potential for use as energetic binders and plasticizers in explosives, as well as a fundamental understanding of the chemistry of these compounds. The work was initiated after discussions with the AF Armament Laboratory and active liaison has been formed between Seiler, the US Naval Ordnance Laboratory, AEC Laboratories and other defense laboratories.

During FY71, the research goal of preparing an homologous series of explosive compounds has been completed. The next phase of this research program will include investigation of the chemical, physical and explosive properties of nitroaliphatic compounds, and will attempt to relate these properties to molecular structure. These investigations include kinetics of decomposition, both thermal and chemical, photochemistry, carbanion character, carbene reactions and spectroscopy.

APPLIED MATHEMATICS

The continuing need for a superior defense capability, requiring increased technological sophistication but offset by growing hardware costs, will require greater precision in the selection, design, evaluation, and employment of future aerospace weapon systems. The necessary precision can be obtained through the ability to treat such systems mathematically.

To meet such challenges, the overall objectives of this research are to devise mathematical techniques and tools applicable to the design and evaluation of improved navigation, guidance, control, and communications systems - specifically: (a) development and refinement of mathematical models for describing appropriate physical phenomena, devices, and systems; (b) investigation and formulation of mathematical and computational methods and algorithms for optimizing or controlling such devices and systems; (c) verification, through experiment and computer simulation, of the models, methods, and algorithms. Results are intended to provide potential solutions for future Air Force technological requirements and advances in avionic communications, flight control, navigation and guidance, surveillance and tracking, and information processing. Research efforts are keyed to and measured against the expressed Research Needs of such organizations as AFAL, AFFDL, AFWL, CIGTF, RADC, ESD, and SAMSO.

FY72 will see increased emphasis on applied mathematics research benefitting inertial navigation, guidance, and control; in particular, development, experimental verification, and refinement of mathematical models of instruments and natural principles which affect and enable navigation, guidance, and control by inertial means, but also including development of improved signal-estimation and filtering processes and flight-control schemes and algorithms applicable to inertial systems as well as other uses. Experimental verification at the new degrees of precision sought will require further improvement of the Inertial Guidance Laboratory in terms of test equipment and laboratory environmental support and controls.

Optimal Flight-Control Schemes: Individual work units are attempting further development of the two-player differential games approach to realistic aerial engagement problems and extension of numerical procedures for solving realistic flight-control problems involving constrained variables. Efforts in differential games research is being directed toward expanding current modeling capabilities to include such things as: higher-order plant equations; noise in the time-delayed player information; N-player involvements with time-delayed player information; and exploitation strategies for the player having full information. Numerical procedures for solving flight-control problems with constrained variables are being expanded to include the development and adaptation of non-linear systems with restricted control and state variables for solutions on hybrid computers.

Linear and Non-linear Estimation, Filtering, and Control Techniques: Emphasis is on non-linear and adaptive methods for processing data from tracking, surveillance, communication, and other telemetry systems. We hope to demonstrate practical non-linear filters and adaptive estimators through research in separate work units. Involved mostly is the necessary simplification of the mathematical descriptions and the subsequent computer simulations to verify the suitability of the design concepts. Some effort is continuing on the further theoretical development of these mathematical models. Non-linear switching controllers are being studied to see if improved performance can result by combining the better features of existing systems. Response and stability of such augmented systems will be simulated on an analog computer.

Inertial, Navigation, Guidance, and Stability Control Schemes and Mechanisms: One unit of work is concentrated on short-term stabilization and the necessary requirements to isolate a stabilized member of a platform from angular vibrations induced by a severe dynamic environment. Angular deviation sensors and their applications to system stabilization feedback-loops are being investigated to isolate and solve the problem areas. A second unit is attempting to determine improved techniques for azimuthal alignments through mathematical modeling. Improved accuracy over a short time period is being sought. A third unit will investigate models of the earth's gravitational potential other than the spherical-harmonics model. Emphasis will be placed on methods for measuring and modeling local anomalies without significantly changing the global potential. Results will be useful in developing schemes for pinpoint navigation to any point on the earth's surface. A fourth unit concerns new mathematical techniques for analysis and evaluation of inertial guidance sensors, including postulation of new excitation methods as well as output data processing at precisions commensurate with specifications for future generations of sensors.

FLUID MECHANICS

Securing and maintaining freedom of movement throughout the aerospace environment will depend on the USAF's ability to master flight throughout that environment. To develop advanced flight vehicles with this capability will require an increased understanding of the physical principles governing and affecting flight at diverse altitudes and speeds. A better knowledge of gas- and aero-dynamic phenomena, including shock-wave structure and characteristics, the behavior of gaseous fluids near solid boundaries, real gas effects, and radiation gas-dynamics, is essential to that understanding.

To meet these needs, this research has as its overall objective the development and verification of new theories in aero- and gas-dynamic phenomena useful to the design of advanced offensive and defensive aerospacecraft and weapon systems, including: mathematical representation of gas-dynamic phenomena and properties; development of diagnostic techniques for visualizing aero-dynamic flows and gas-dynamic phenomena; experimental determination of gas-dynamic characteristics. Results are intended to provide potential solutions for future Air Force technological requirements in flight mechanics and control, vehicle and ordnance configuration, advanced propulsion, and advanced weaponry. Research efforts address and are measured against documented Research Needs of such organizations and agencies as AFFDL, AFATL, AFWL, SAMSO, ARPA, and NASA.

There will be in FY72 a noticeable shift in emphasis from analytical to experimental research. Specific experiments will be conducted to investigate radiative properties of gas molecules, vapors, and engineering surfaces; the occurrence and behavior of electric-current sheets in gases; lift and vortex-shedding properties of close-coupled canard-delta wing configurations; pitch and bounce behavior of the ram-wing surface-effect vehicle; static and dynamic stability of ballistic projectiles; performance of supercritical wing configurations in the transonic regime; and real gas effects at hypersonic speeds.

To support these studies, the Frank J. Seiler Research Laboratory low-density shock tube will be modified to make it useful for low-cost studies of aerodynamics and real-gas effects occurring at supersonic and hypersonic speeds. Two complimentary alterations are planned: a Ludwig-tube modification, which will permit low-cost aerodynamic studies at supersonic speeds, and addition next year of a high-pressure driver which will extend the tube's experimental limits enabling studies of gas effects at increased hypersonic speeds.

USAF ACADEMY FACULTY RESEARCH SPONSORED BY FJSRL

FJSRL sponsors twenty three active research projects involving faculty members from the following academic departments: Department of Chemistry (DFC), Department of Life Sciences (DFLS), Department of Physics (DFP), Department of Civil Engineering (DFCE), Department of Engineering Mechanics (DFEM), Department of Aeronautics (DFAN), Department of Astronautics and Computer Sciences (DFAST), and Department of Electrical Engineering (DFEE).

Colonel R. R. Bate and Captain R. L. Fretwell, Department of Astronautics and Computer Sciences, are developing a higher-order programming language

for use on the IRAM airborne computer and other similar airborne computers. This project will have direct benefit to the Air Force, in particular to SAAMA and ADC, in that it will provide a method of programming airborne computers superior to any previously attempted and, thereby, add flexibility and efficient to the development and modification of airborne computer applications.

Major William H. Boss, Department of Aeronautics, is studying the static and dynamic aerodynamic characteristics of ballistic shapes and the influence of those characteristics on the flight trajectories and impact points of USAF ordnance. Static stability derivatives of bomb shapes will be determined through wind-tunnel tests at subsonic and transonic speeds and at large angles of attack where non-linearities become significant. Dynamic testing devices will be developed and used to devise analytical programs which relate such characteristics to bomb trajectories. Recommendations for new shapes or stability and control methods for USAF ordnance will be made based upon results of this study.

Major R. W. Burton, Department of Electrical Engineering, is attempting to measure current distributions and admittances of plasma-immersed cylindrical antennas. This experimental substantiation of theoretical models of the influence of plasma sheaths on antenna properties will allow evolution of new radiating systems for communications applications.

Colonel P. B. Carter, Department of Life Sciences, is investigating two aspects of human performance. The first research effort is to identify the physiological parameters associated with "cardio-pulmonary fitness", measure these parameters, and attempt to explain their role in physical fitness. Emphasis is being placed on the role of attitude in physical fitness, and a data bank of cardio-pulmonary responses at an altitude of 7,000 feet is being accumulated. One of the primary objectives of this research is to provide a sound basis for an adequate Air Force physical fitness program.

Colonel Carter's second research effort is devoted to a study of individuals having incomplete right bundle branch blocks. Using a Vector Electrocardiograph as a principal tool, he is following the progress of incomplete blocks through various stages to complete blocks. Emphasis is being placed on the roles of altitude and other stresses. As the result of this investigation, the influence (if any) of a right bundle branch block on physiological performance will be more clearly understood.

Major Richard E. Fitts, Department of Electrical Engineering, and several USAFA cadets are investigating nonlinear systems which occur in the design of control systems for aerospace vehicles and have the ability to generate unique wave forms. The participants will construct and analyze analog systems which have this behavior and attempt to develop theoretical explanations. This effort will increase our understanding of these non-linear systems and improve our ability to design aerospacecraft flight controls incorporating such systems.

Capt Carl Forbrich of the Department of Aeronautics, is studying refraction methods for predicting properties of vaporized materials. State-of-the-art methods for discrimination of reentry vehicles, such as ballistic warheads, in the 1980s might be based on optical methods in which knowledge of atomic oscillator strengths is essential. An experimental apparatus to refine

refraction techniques for measuring oscillator strength was designed and assembled in 1969 by Capt Forbrich. This year he is taking experimental measurements with emphasis on atomically-heavy gases and vapors. Capt Forbrich is expected to be reassigned to FJSRL during January 1972.

Capt Roger W. Gallington, Department of Aeronautics, is extending research he initiated while assigned to FJSRL on the exchange of energy and momentum in weakly-ionized plasma sheets and on aero-dynamic theories for the Ram-Wing high-speed ground-effect vehicle.

Some of the projects in the Department of Physics are fundamental in nature. As an example, Capt J. H. Head is conducting an experimental investigation of nuclear decay schemes. Target nuclei of particular interest include Lutetium-176, Holmium-165 and several isotopes of Dysprosium. The targets are activated by neutrons or other particles, and the decay processes of the product nuclei are followed with a variety of detection equipment. The data are processed by numerical techniques to yield nuclear decay schemes and reaction cross sections.

Capt J. N. Jensen, Department of Physics, is studying the effects of CO₂ laser radiation on aluminum samples coated with aluminum oxide. The amount of energy absorbed by the sample is being measured, and from this datum the reflectivity is being determined. A variety of different samples are being used; parameters of interest include degree of polish, surface roughness, and thickness of the aluminum oxide layer.

Capt J. King, Department of Physics, is measuring physical properties of liquid crystals in an effort to provide insight into the intermolecular forces which govern the unique properties of these materials. Initially, nuclear relaxation times are being measured over a range of temperatures. Eventually, optical methods, electron paramagnetic resonance, Mössbauer spectroscopy, electron microscopy, X-Ray diffraction, and other techniques will be applied to the task. The ultimate objective is to provide a scientific basis for understanding the response of liquid crystalline materials to electromagnetic radiation and other environments.

The effects of radiation on materials are also being investigated. Major L. G. Kirchner, Department of Physics, has modified a transmission electron microscope and adapted it to the study of electron channeling. Particular emphasis is being placed on the channeling through ultrathin single crystals of silicon. The objective of the research is to better understand the failure mechanisms for semiconductor devices in radiation environments.

Capt R. Kosak, Department of Engineering Mechanics, is studying the wettability of single crystal alumina filaments by a series of cobalt alloys. The sessile drop method is being used, and the shear strength of the bond between the alloy and the alumina is also being measured. In an extension of the investigation, the effect of adding reactive metals to the cobalt will also be studied. The objective of the overall project is to develop filament reinforced structures for applications such as turbine blades. Such structures would permit higher operating temperatures and a net weight reduction of the engine, and thus increase gas turbine efficiency.

Lt L. J. Larson, Department of Engineering Mechanics, is studying the control and arrest of cracking in laminated materials. His objective is to develop an

analytical model of the stress state surrounding a crack tip as it approaches a material interface, thereby increasing understanding of the mechanics of crack arrest in laminated materials and enabling improved structural designs incorporating material bonds to resist mechanical failure.

Mr. Ralph D. Marker, Director of the USAF Academy's Aeronautical Laboratories, is investigating, under joint sponsorship of FJSRL and the AF Weapons Laboratory, the diffusion of a light gas injected into a supersonic rarified heavy-gas stream. The results will provide improved knowledge of gas-dynamic characteristics at the exit of a slit nozzle enabling analysis of flow characteristics in a chemical laser.

In a search for new alloys suitable for advanced aircraft and rocket engines, Maj J. M. McCormack, Department of Engineering Mechanics, is studying the thermodynamic properties of rare earth metals and their alloys. Metals of particular interest are erbium, gadolinium, dysprosium, samarium, ytterbium, and holmium. The Knudsen effusion technique is being used to obtain vapor pressure data for these metals up to a temperature of 2000°C. From the vapor pressure data, the chemical activities and related thermodynamic properties of the metals will be determined. The results of this investigation will facilitate selection and development of suitable high temperature alloys of rare earth metals.

Several projects are devoted to the study of new materials. Capt M. W. Moore, Department of Chemistry, is studying the chemistry of difunctional phosphinic acids and related compounds. The ultimate objective is to develop methods for making metal containing polymeric materials having high thermal stability and mechanical strength.

Major C. H. Robison, Department of Physics, is conducting studies of the superconducting transition in lead as a function of magnetic field and of temperature. Both solid and powdered samples are being studied, and the effects of voids and of paramagnetic impurities are being investigated.

In another project involving CO₂ lasers, Major Robison is studying the feasibility of using negative branch unstable optical resonators for Air Force applications in which large amounts of power must be coupled out of the laser. A negative branch unstable optical resonator is being built and its sensitivity to variation of geometric parameters will be investigated. In particular, studies will be made of the influence of geometry on output coupling, beam pointing, far field intensity, beam power and mode structure.

Major S. E. Schultz, Department of Civil Engineering, is engaged in two projects concerned with water treatment and quality. The first project is to develop for the USAF Academy a water pollution abatement and monitoring program which will serve as a model for other US Air Force installations. Parameters under investigation include the sampling network, instrumentation and testing procedures for determining the physical, chemical and biological properties of water resources.

In a related program, Major Schultz is studying the practicality of using chlorine to disinfect effluents from sewage stabilization ponds having a high organic loading. At the same time, new techniques are being developed for determining the concentration of indicator organisms in these algae-laden effluents.

Major M. J. Stansell, Department of Life Sciences, is developing a technique, using electromagnetophoresis, for rapid and accurate identification of Gun-Hill Hemoglobin. The research takes advantage of the fact that, although both

Gun-Hill Hemoglobin and S Hemoglobin have the same electrophoretic mobilities, Gun-Hill Hemoglobin has two less heme groups than does S Hemoglobin. Hence, when both are converted to paramagnetic forms, the Gun-Hill Hemoglobin should move less rapidly in a magnetic field. The ultimate objective of the research is to develop a procedure which will permit rapid differentiation of Gun-Hill hemolytic anemia from sickle cell trait or disease.

Major L. W. Stockham, Department of Aeronautics, is investigating the radiative properties of surfaces and surface coatings under various conditions of illumination. His objective is to develop coherent-light reflectance-function information to provide insight into possible defenses against advanced electromagnetic weapons and sensing devices.

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8. Lt Col Bernard S. Morgan, Jr. SRL 65-0004 (AD-625010), Computational Procedures for Sensitivity Coefficients in Time-Invariant Multivariable Systems. 13 Oct 65.
9. Capt Daniel D. Traficante SRL 65-0005 (AD-624405), Carbon-13 Magnetic Resonance of 1-substituted, 1-Hexynes. 1 Apr 65.
10. Capt Daniel D. Traficante SRL 65-0006, (AD626009), Carbon-13 Magnetic Resonance Study of the Protonation of Acetic and Benzoic Acids and their Ethyl Esters in Concentrated Sulfuric Acid. Mar 65.

11. Capt Daniel D. Traficante SRL 65-0007 (AD 627875), Fluorine-19
Magnetic Resonance Study of Secondary
Deuterium Isotope Effects of the
Methyl Group. Jun 65.
12. 1st Lt Allan F. Schanzle SRL 65-0009 (AD627653), Regularization
and Power Series Solution for the
Third Order Representation of the
Restricted 3 Body Problem. Dec 65.
13. Lt Col Orlando J. Mancini, Jr. SRL 65-0010 (AD 641155), Differential
Analyzer Solution of the Diffusion
Equation with a Free Boundary. Oct 65.
14. Dr. Gennedy M. Kosolapoff SRL 65-0011 (AD 630657), Methods of
Formation of P-C Bonds in Tertiary
Phosphine Oxides. Nov 65.
15. Maj Rinaldo F. Vachino SRL 66-0001 (AD642473) Steepest
Descent with Inequality Constraints
on the Control Variables.
16. 1st Lt Gerald Cook and
Lawrence Stark SRL 66-0002 (AD 643579), Dynamics of
the Saccadic Eye-Movement Mechanism.
Jun 66.
17. 1st Lt William R. Alford SRL 66-0003 (AD 639579), Uncountably
Many Different Involutions of S^3 .
Feb 66.
18. Lt Col Bernard S. Morgan, Jr. SRL 66-0004 (AD 646401), Sensitivity
Analysis and Synthesis of Multivariable
Systems. Jul 66.
19. Capt Dirk H. deDoes SRL 66-0005 (AD 806380), Time-Optimal
Attitude Control of a Spinning Vehicle.
Jul 66.
20. Capt Charles F. Stebbins
and Capt Douglas S.
Johnson SRL 66-0006 (AD 635305), Design,
Construction and Calibration of the
FJSRL 17" Low Density Shock Tube.
May 66.
21. Capt James E. Funk and
Margerita B. Miller SRL 66-0007 (AD 489911), SLASH-3.
Aug 66.
22. 1st Lt Gerald Cook and
Capt James E. Funk SRL 66-0008 (AD 643495), Quadratic
Control Problem with an Energy
Constraint: Approximate Solutions.
Oct 66.
23. Lt Ralph W. Rudolph and
R.W. Perry SRL 66-0009 (AD 641686), Fluoropho-
sphine Ligands. Parts I, II, III, and
IV.

24. Capt Daniel D. Traficante and Gary E. Maciel SRL 66-0010 (AD 649909), Carbon-13 Chemical Shifts of Carboxyl Species from Acetic, Benzoic and Mesitoic Acids in Sulfuric Acid and Oleum Solutions. Apr 66.
25. Lt Clair J. Cheer and Carl R. Johnson SRL 66-0011 (AD 654821), A Ring-Expansion. The Rearrangement of 1-Isopropenylcycloalkanol Epoxides. Sep 66.
26. Lt Ralph W. Rudolph SRL 67-0001 (AD 663009), The Mechanism Addition of Diboron Tetrachloride to Unsaturated Organic Compounds. Aug 67.
27. Karl G. Brammer SRL 67-0003 (AD 650641), Lower Order Linear Filtering and Prediction of Nonstationary Random Sequences. Feb 67.
28. Capt Dirk H. deDoes SRL 67-0004 (AD 652221), Time-Optimal Attitude Control of a Spinning Vehicle. Mar 67.
29. 1st Lt Gerald Cook and Lawrence Stark SRL 67-0005 (AD664626), The Human-Eye Movement Mechanism: Experiments, Modeling and Model Testing. Jun 67.
30. Capt Charles F. Stebbins SRL 67-0006 (AD654013), Experiments on Transverse Ionizing MHD Shock Waves. May 67.
31. Lt Col Bernard S. Morgan, Jr. SRL 67-0007 (AD658022), Design for Maintenance of the System Band width in the Presence of Parameter Changes. Mar 67.
32. Maj James M.L. Karns SRL 68-0001 (AD671507), An Intertemporal Analysis of the Defense Impact Upon a Local Community: Case Study of El Paso County. Jan 68.
33. Maj Rinaldo F. Vachino SRL 68-0002 (AD 839963), A Generalized Steepest Descent Algorithm for Multi-state Optimization Problems. Apr 68.
34. 1st Lt Gerald Cook SRL 68-0003 (AD 665151), An Approximation Technique for Singular Control Problems. Dec 67.
35. 1st Lt David Finkleman SRL 68-0004 (AD 666413), A Characteristics Approach to Radiation Gas Dynamics. Jan 68.
36. Capt Clair J. Cheer and Carl R. Johnson SRL 68-0005 (AD 666100), The Stereoselective Rearrangements of Conformationally Mobile Epoxides. Jan 68.

37. Capt Charles F. Stebbins SRL 68-0006 (AD 680447), An Iterative Computational Scheme for Predication Gasdynamic Properties Across a Transverse Ionizing Shock Wave in Hydrogen. Oct 68.
38. 1st Lt J.M. Veigel SRL 68-0007 (AD 667177), The Acid-Catalyzed Aquation of the α -Oxalato-triethylenetetraminechromium (III). Mar 68.
39. Capt Roger W. Gallington SRL 68-0008 (AD 685748), The Structure of an Electric Current Carrying Wave Separating Two Uniform Non-Conducting States in a Gas. Oct 68.
40. Lt Col Charles K. Arpke,
Dr. Hans Reich, Maj Robert
W. Lamb and Dr. G. Kosolapoff SRL 68-0009 (AD 674814), Structural Effects in Reactions of Organophosphorus Compounds I. Reactions of Phosphorus Oxychloride with Indered Phenols. Jun 68.
41. Maj A.D. Brown, Jr. and
Dr. G.M. Kosolapoff SRL 68-0010 (AD 675352), Structural Effects in Reactions of Organophosphorus Compounds II. Reaction of Grignard Reagents with Phosphonic Dichlorides. Jun 68.
42. Capt Ralph W. Rudolph and
Capt H.W. Schiller SRL 68-0011 (AD 674807), The Preparation of Phosphine-Difluorophosphine. A High Yield Synthesis of Difluorophosphine. Jun 68.
43. 1st Lt David Finkleman SRL 68-0012 (AD694480), Numerical Studies in Semi-Gray Radiative Gasdynamics. Feb 69.
44. 1st Lt Jon M. Veigel SRL 68-0014 (AD 674813), Accurate Temperature Control of the Beckman DK-2 Recording Spectrophotometer. Jan 68.
45. Capt John F. Schaefer SRL 68-0015 (AD 674913), Artificial Satellite Orbit Shifting without Mass Expulsion Utilizing Gravity Gradient. Sep 68.
46. Capt John F. Schaefer SRL 68-0016 (AD 674935), Chatter Motion of Bang-Bang Controllers. Sep 68.
47. Maj R.F. Vachino, Capt J.F.
Schaefer, Capt D.H. deDoes,
Lt Col B.S. Morgan, Jr. and
1st Lt G. Cook SRL 68-0017 (AD 674900), The Application of the Method of Steepest Descent to a Pursuit-Evasion Problem. Aug 68.

48. Maj L. A. King
Capt J. F. Altenburg
Carolyn Campbell
SRL 68-0018 (AD680314), Computer Grading of General Chemistry Laboratory Reports. Sep 68.
49. Major Roger Geesey
SRL 69-0001 (AD698765), Canonical Representations of Second-Order Processes with Application. Jan 69.
50. Capt Charles F. Stebbins
George C. Vlases
SRL 69-0002 (AD694340), An Experimental Study of Transverse Ionizing MHD Shock Waves. Feb 69.
51. Capt David Finkleman
SRL 69-0004 (AD695168), A Note on Boundary Conditions for Use with the Differential Approximation to Radiative Transfer. Oct 69.
52. Lt Col Robert W. Milling
SRL 69-0005 (AD694481), Use of Time Resolved Raman Scattering for the Measurement of Dissociation Rates in a Shock Tube. Jun 69.
53. Capt Michael D. Giletti
SRL 69-0006 (AD693754), Composition Problems for Differential Games. Jun 69.
54. Capt Roger Gallington
Capt David Finkleman
SRL 69-0007 (AD710497), Determination of Realistic Performance Trade-Off's in the Air to Air Role. Jul 70.
55. Lt Col John Paul Hyde
1Lt Joseph E. Justin
SRL 69-0008 (AD723649), Simulation of the Snap-Shoot Gunsight. Apr 71.
56. [REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
57. Maj Roger Geesey
SRL 69-0010 (AD694482), Applications of the Canonical Representations to Estimation and Detection in Colored Noise. Jun 69.
58. Capt Richard Voorhees
Capt Ralph Rudolph
SRL 69-0011 (AD693755), A 3-Carbon Carborane Analog, 1-Stanna-2, 3-dicarbo-closo-dodecarborane(11). Jul 69.
59. Capt Dirk H. deDoes
SRL 69-0012 (AD694483), Time-Optimal Attitude Control of an Axially Symmetric Spinning Spacecraft. Jun 69.
- [REDACTED]
- [REDACTED]

61. Capt Dirk H. deDoes
Maj John Schaefer
Lt Col Bernard Morgan, Jr.
Lt Gerald Cook
SRL 69-0015 (AD696888), Procedures to Check the Adjoint Equations When Using the Method of Steepest Ascent. Oct 69.
62. Gennady M. Kosolapoff
A. D. Brown, Jr.
SRL 70-0001 (AD702348), Reaction of Alkali with Phosphite Esters. Dec 69.
63. Richard A. Newmark
Arlen D. Norman
Ralph W. Rudolph
SRL 70-0002 (AD702224), Temperature Dependent Geminal P-P Coupling Constants. Dec 69.
64. Gennady M. Kosolapoff
Alfred D. Brown, Jr.
SRL 70-0003 (AD702225), Some Unexpected Chlorophosphate Chemistry. Dec 69.
65. Ralph W. Rudolph
Richard A. Newmark
SRL 70-0004 (AD706153), Signs and Temperature Dependence of the Coupling Constants in F_2PPF_2 , F_2PSPF_2 , and $MeN(PF_2)_2$. Aug 69.
66. Lt Col John Paul Hyde
SRL 70-0005 (AD717427), A Concise Expression for the Switching Coefficients for Positive-Negative Feedback Systems. Jan 71.
67. Lt Col John Paul Hyde
SRL 70-0006 (AD711711), Restrictions on Switching in Positive-Negative Feedback Control System. Sep 70.
68. Capt Michael D. Ciletti
SRL 70-0007 (AD707284), On the Contradiction Bang-Bang-Bang Surfaces in Differential Games. Mar 70.
69. Alfred D. Brown, Jr.
Hans Reich
SRL 70-0008 (AD708065), Reductive Cleavage of Ferrocene Derivatives. Jul 69.
70. R. S. Bucy
Kenneth D. Senne
SRL 70-0010 (AD709195), Digital Synthesis of Nonlinear Filters. Jul 70.
71. Ralph W. Rudolph
R. L. Voorhees
R. E. Cochoy
SRL 70-0011 (AD711228), The Preparation and Characterization of 1-Germa, 1-Stanna-, and 1-Plumba-2, 3-dicarba-closo-dodecaborane(1). Jul 70.
72. Capt Michael D. Ciletti
Alan W. Starr
SRL 70-0012 (AD711658), Differential Games: A Critical View. Aug 70.
73. Capt Kenneth D. Senne
SRL 70-0013 (AD712101), New Results in Adaptive Estimation Theory. Apr 70.
74. Capt Kenneth D. Senne
SRL 70-0014 (AD713098), An Exact Solution to an Adaptive Linear Estimation Problem. Sep 70.
75. Capt Roger W. Gallington
2Lt Mark K. Miller
SRL 70-0015 (AD715557), The Ram-Wing: Comparison of Simple One-Dimensional Theory with Wind Tunnel Free Flight Results. Dec 70.

76. Capt Michael D. Ciletti SRL 70-0016 (AD715905), New Results in the Theory of Differential Game with Information Time Lag. Oct 70.
77. R. W. Rudolph SRL 70-0017 (AD715558), The Crystal and Molecular Structure of 1,2'; 1', 2-Di- μ -carbonyl-bis[1,2-dicarba-closo-dodecaborane(12)]. Oct 70.
L. Pflug
C. Bock
M. Hodgson
78. Capt Dino A. Lorenzini SRL 70-0018 (AD715906), A New Gyroscope Centrifuge Test. Dec 70.
79. Capt David Finkleman SRL 71-0001 (AD719744), Nonequilibrium Radiative Gas Dynamics of Pointed Bodies. Feb 71.
80. Capt David Finkleman SRL 71-0002 (AD720821), New Interpretations of Normal Shock Wave Structure in Radiating Gases. Mar 71.
81. Capt David Finkleman SRL 71-0003 (AD719742), Nonlinear Vortex Interactions on Wing-Canard Configurations. Feb 71.
82. Capt John F. Schaefer SRL 71-0004 (AD719743), A New Adaptive Control Technique. Feb 71.
83. Capt David Finkleman SRL 71-0005 (AD723728), Generalized Differential Approximations in One-Dimensional Radiative Transfer. Mar 71.
84. D. W. Seegmiller SRL 71-0006 (AD720436), Preparation of Crystals of Aluminum Chloride. Aug 70.
G. W. Rhodes
L. A. King
85. L. A. King SRL 71-0007 (AD721791), Liquid and Vapor Densities of Aluminum Chloride. Oct 70.
D. W. Seegmiller
86. Maj George R. Hennig SRL 71-0008 (AD721705), A Numerical Method for the Solution of Optimal Control Problems with Bounded State Variables. Apr 71.
87. James M. McCormack SRL 71-0009 (AD), Vapor Pressure of Dysprosium and Erbium. Apr 71.
Peter R. Platt
Richard K. Saxer
88. Capt Michael D. Ciletti SRL 71-0010 (AD), Results in the Theory of Linear Differential Games with an Information Time Lag. May 70.

PAPERS PRESENTED

Lt Col O.J. Mancini, Jr. "Differential Analyzer Solution of the Diffusion Equation with a Free Boundary", International Symposium on Analogue and Digital Techniques Applied to Aeronautics, Liege, Belgium, 9-12 Sep 63.

Lt Col O.J. Mancini, Jr. "Minimum Fuel Trajectories with Soft Landings", 11th Annual Science and Engineering Symposium, Brooks AFB, Texas, 20 Oct 64.

Capt James E. Funk "SLASH", Southeastern Simulation Council Meeting, 22 Mar 65.

Maj Rinaldo F. Vachino "Steepest Descent with Inequality Constraints on the Control Variables", First International Conference on Programming and Control, USAF Academy, Colorado, Apr 65.

Lt Col Bernard S. Morgan, Jr. "Computational Procedures for Sensitivity Coefficients for Multi-variable Systems", 3rd Annual Allerton Conference on System and Circuit Theory, Monticello, Illinois, 21 Oct 65.

Maj Rinaldo F. Vachino "A Computational Procedures for Optimum Trajectory and Optimum Control Problems", OAR Research Applications Conference, Washington DC, 5 Apr 66.

Lt Col Orlando J. Mancini, Jr. "Minimum Fuel Trajectories with Soft Landings", Region Six IEEE Conference, Tucson, Arizona, 27-28 Apr 66.

Capt John F. Schaefer "On the Control of Unstable Mechanical Systems", IFAC Conference, London, England, 23 Jun 66.

1st Lt Gerald Cook (by proxy) "Dynamics of the Saccadic Eye-Movement Mechanism", Symposium on Biomedical Engineering, Marquette University, 25 Jun 66.

Capt Dirk H. deDoes "Time Optimal Position and Velocity Control of a Spinning Vehicle", AAS Space Flight Mechanics Specialist Conference", Denver, Colorado, 7 Jul 66.

Lt Ralph W. Rudolph "The Preparation and Characterization of New Difluorophosphine Ligands", Junior Officer Science and Engineering Symposium, Brooks AFB, Texas, 24 Aug 66.

Lt Ralph W. Rudolph "Fluorophosphine Ligands III. Syntheses involving PF_2I . The Preparation and Characterization of u-oxo-bisdifluorophosphine, Cyanodifluorophosphine and Tetrafluorophosphine", 152nd National Meeting of the American Chemical Society, Sep 66.

Capt John F. Schaefer "Adaptive Bang-Bang Control of an Unstable Mechanical System Containing and Unknown Parameter", 13th Annual Science and Engineering Symposium, Arnold AFS, Tennessee, 20 Sep 66.

1st Lt Jon M. Veigel "Synthesis and Aqutation Kinetics of cis-chlorisothiocynatobis-(ethylene-diamine)chromium(III)-cation and of cis and trans-isothiocynatoaquobis (ethylenediamine)-chromium(III)cations", 150 ACS Meeting, Atlantic City, New Jersey, Sep 65.

1st Lt Gerald Cook "Quadratic Control Problem with an Energy Constraint", 4th Allerton Conference on System and Circuit Theory, Monticello, Illinois, 6 Oct 66.

Capt John F. Schaefer "Artificial Satellite Orbit Shifting Using Gravity Gradient", XVII International Astronautical Congress, Madrid, Spain, 11 Oct 66.

Capt Charles F. Stebbins "Experiments on Transverse Ionizing MHD Shockwaves", American Physical Society, 8th Annual Plasma Physics Meeting, Boston, Massachusetts, 3 Nov 66.

Lt Col Bernard S. Morgan, Jr. "Multivariable System Sensitivity", 4th Winter Institute, University of Florida, 22 Feb 67.

Maj Rinaldo F. Vachino "Computational Aspects of the Steepest Descent Solution of Multistage Optimization Problems", 4th Winter Institute, University of Florida, 22 Feb 67.

Capt John F. Schaefer	"Computational Requirements Associated with the Control of Unstable Systems", 4th Winter Institute, University of Florida, 22 Feb 67.
Lt Col Bernard S. Morgan, Jr.	"The Design for Maintenance of the Systems Bandwidth in the Presence of Parameter Variations", 1st Annual Princeton Conference on Information Sciences and Systems, Princeton University, 31 Mar 67.
Maj Lowell A. King	"Computer Grading of General Chemistry Laboratory Reports", Colorado-Wyoming Academy of Science, Boulder, Colorado, 28 Apr 67.
Capt Ronald J. Penick	"Optical Split Screen in Video", The American Chemical Society Meeting, Miami Beach, Florida, 12 Apr 67.
Capt Ronald J. Penick	"Ionization Studies on N-Acetyl-Neuraminic Acid and Purified Gangliosides", Colorado-Wyoming Academy of Science, Boulder, Colorado, 28 Apr 67.
Maj Rinaldo F. Vachino	"A Generalized Steepest Descent Technique for Multi-state Optimization Problems", Seminar on Guidance Theory and Trajectory Analysis, Electronics Research Center, NASA, Cambridge, Massachusetts, 31 May 67.
Lt Col Bernard S. Morgan, Jr.	Invited Discussor at the 1967 Joint Automatic Control Conference, University of Pennsylvania, of the paper, "The Optimal Feedback Control of a Launch Vehicle to Reduce Trajectory Sensitivity", 29 Jun 67.
Lt Col Bernard S. Morgan, Jr.	Invited Discussor at the 1967 Joint Automatic Control Conference, University of Pennsylvania, of the paper, "The Decoupling of Multivariable Systems", 30 Jun 67.
Lt Col Bernard S. Morgan, Jr.	Invited Discussor at the 1967 Joint Automatic Control Conference, University of Pennsylvania, of the paper, "Modeling and Compensation of Nonlinear Systems Using Sensitivity Analysis", 29 Jun 67.

Capt John F. Schaefer	"A New Adaptive Technique", 1967 Joint Automatic Control Conference, University of Pennsylvania, 29 Jun 67.
Capt Roger Gallington	"The Structure of a Moving Electric Current Carrying Discontinuity Separating Uniform Non-Conducting States in a Gas", AAS Rocky Mountain Resources for Aerospace and Technology Conference, Denver, Colorado, 13 Jul 67.
Capt Dirk H. deDoes	"Computer Optimization Study of a Tactical Aircraft-Missile Engagement", Symposium on the Analysis and Design of Fighter Systems for Air-to-Air Combat", The Rand Corporation, Calif- ornia, 11 Jan 68.
Maj R.E. Willes and Maj A.E. Preyss	"Air Combat Maneuvering", Symposium on the Analysis and Design of Fighter Systems for Air-to-Air Combat", the Rand Corporation, California, 12 Jan 68.
Maj Ray E. Chapman	"Computer Hardware, Present and Future - An Overview", Pikes Peak Chapter, Association for Computing Machinery, 12 Jan 68.
Lt David Finkleman	"A Characteristic Approach to Radiation Gasdynamics", AIAA Meeting, New York, 27 Jan 68.
Maj Jack A. Winstead	"Effect of Cupric Ions on the Radiolytic Inactivation of Lactate Dehydrogenase", ACS Meeting, Sep 68.
Capt George J. Gauthier	"Studies in Organometallic Chemistry-A Novel Synthesis of Ruthenocene", AF Science and Engineering Symposium, 30 Oct 68.
Maj L.A. King and Maj D.W. Seegmiller	"Densities of Aluminum Chloride-Sodium Chloride Melts", Rocky Mountain Division, American Association for the Advancement of Science and Colorado-Wyoming Academy of Science, Colorado Springs, Colorado, 8 May 69.
Maj L.A. King and Maj D.W. Seegmiller	"Liquid and Vapor Densities for Molten Aluminum Chloride-Sodium Chloride Mixtures", Northwest Regional Meeting, American Chemical Society, Salt Lake City, Utah, 12 Jun 69.

Lt Col Bernard S. Morgan, Jr.	"The Application of Modern Optimization Techniques to a Pursuit-Evasion Problem", Second Annual Princeton Conference on Information Sciences and Systems, Princeton University, March 1968.
Maj John F. Schaefer	"Chatter Motion of Bang-Bang Controllers", Second Annual Princeton Conference on Information Sciences and Systems, Princeton University, March 1968.
Lt Gerald Cook	"An Approximation Technique for Singular Control Problem", Second Annual Princeton Conference on Information Sciences and Systems, Princeton University, March 1968.
Capt Dirk H. deDoes	"The Optimal Solution of a Tactical Pursuit-Evasion Problem", OAR Research Applications Conference, March 1968.
Lt Michael D. Ciletti	"Functional Analysis and an Imperfect Information Differential Game", Eleventh Midwest Circuit Theory Symposium, Notre Dame University, May 1968.
Lt Col Bernard S. Morgan, Jr.	"The Decoupling of Multivariable Systems by State Variable Feedback", by E.G. Gilbert, Invited Discussion, 1968 Joint Automatic Control Conference, University of Michigan, June 1968.
Capt Dirk H. deDoes	"The Application of the Method of Steepest Descent to a Pursuit-Evasion Problem", 1968 AIAA Guidance, Control and Flight Dynamics Conference, Pasadena, California, Aug 1968.
Lt Michael D. Ciletti	"The Composition Problem for Differential Games", Sixth Annual Allerton Conference on Circuit and System Theory, Monticello, Illinois, Oct 1968.
Lt Col Bernard S. Morgan, Jr.	"Application of the Method of Steepest Descent to a Very High Order Optimization Problem", Sixth Annual Allerton Conference on Circuit and System Theory, Monticello, Illinois, Oct 1968.
Capt Dirk H. deDoes	"A Computer Optimization Study of a Three Dimensional Model of an Engagement Between a Surface-to-Air Missile and a Tactical Aircraft", 1968 AF Science and Engineering Symposium, USAF Academy, Oct 68.

Lt Michael D. Ciletti	"The Application of the Theory of Differential Games to Problems in Air-to-Air Combat", 1968 OAR Research Applications Conference, 13 Mar 69.
Lt Gerald Cook	"An Approximation Technique for Singular Control Problems", 1969 IFAC Congress, Warsaw, Poland, Jun 69.
Capt David Finkleman	"Generalized Differential Approximations in Radiative Transfer", AAS/ORSA Meeting, Denver, Colorado, June 1969.
Capt Roger A. Geesey	"Application of the Canonical Representation of Second Order Processes to Estimation and Detection in Colored Noise", PIB Symposium on Computer Processing in Communications, 9 Apr 69.
Lt Michael D. Ciletti	"A Differential Game with an Information Time Lag", Purdue Centennial Year Symposium on Information Processing, 28 Apr 69.
Lt Michael D. Ciletti	"Numerical Studies in Realistic Differential Games", Purdue Centennial Year Symposium on Information Processing, 28 Apr 69.
Lt Kenneth D. Senne	"Adaptive Discrete-Time Estimation", Purdue Centennial Year Symposium on Information Processing, 30 Apr 69.
Maj Roger Geesey	"Some General Solutions to the Problem of Covariance Factorization", 1969 IEEE International Symposium on Information Theory, Jan 1969.
Capt Michael Ciletti	"A Differential Game with an Information Time Lag", Invited paper - First Intl. Conference on the Theory and Applications of Differential Games, Amherst, Mass., Sep 69.
Major John Hyde	"A Concise Expression for the Switching Coefficients for Positive-Negative Feedback Systems", Seventh Annual Allerton Conference on Circuit and System Theory, U. of Ill., 8-10 Oct 69.
Capt David Finkleman	"Generalized Differential Approximations in One-Dimensional Radiative Transfer", ASME Winter Annual Meeting, Los Angeles, Calif., 16-20 Nov 69.

Capt Raymond R. McGuire
M. J. Zabik
R. D. Schuetz
R. D. Flotard

"Photochemistry of Bioactive Compounds I. The Photolysis of Heptachlor: Cage Formation Versus Photodechlorination", American Chemical Society National Meeting, New York, New York, 9 Sep 69.

Lt Col Lowell A. King
Maj David Seegmiller
Capt David Olson

"The Triple Point of Aluminum Chloride", Southwest Regional ACS Meeting, Tulsa, Oklahoma, 4 Dec 69.

Capt Michael Ciletti

"A Differential Game With an Information Time Lag", Third Intl Conference on System Sciences, Univ of Hawaii, 14-16 Jan 70.

Capt Kenneth Senne
R. S. Bucy

"Passive Receiver Design via Nonlinear Filtering", Third Intl Conference on System Sciences, Univ of Hawaii, 14-16 Jan 70.

Capt Kenneth Senne
R. S. Bucy

"Digital Realization of Optimal Discrete-Time Nonlinear Estimators", Fourth Annual Princeton Conference on Information Sciences and Systems, Princeton Univ., 26-27 Mar 70.

Capt David Finkleman
Capt Roger Gallington

"The Ludwig Tube in Engineering and Science", AAAS Southwestern Region Annual Meeting, Apr 70.

Capt David Finkleman

"Prediction of Spherically Symmetric Radiative Fields in Astrophysics and Engineering", AAAS Southwestern Region Annual Meeting, Apr 70.

Lt Col Lowell A. King
Maj David Seegmiller
Capt F. N. Frayer

"Electric Conductivity in Molten Salt Mixtures of $AlCl_3/NaCl$ ", Colorado-Wyoming Academy of Science, Greeley, Colo., May 70.

Maj G. Dana Brabson
Mr. J. Lloyd Pflug
Cadet P. A. Bauer
Cadet R. H. Downing
Cadet W. E. Stanland
Cadet R. L. Vaughn

"Systematic Investigation of Alpha-Substituted Acetophenones", Colorado-Wyoming Academy of Science, Greeley, Colo., May 70.

Lt Col Lowell A. King
Maj David Seegmiller
Capt G. W. Rhodes
Capt David Olson

"Some Physical Properties of Aluminum Chloride", Colorado-Wyoming Academy of Science, Greeley, Colo., May 70.

Capt Raymond McGuire
M. J. Zabik
B. E. Pape
R. D. Schuetz
R. D. Flotard

"Photochemistry of Bioactive Compounds III, The Photochemistry and Gas Chromatography-Mass Spectrometry of Heptachlor and Triplet Sensitizer Generated Heptachlor Adducts in Hydrocarbon Solvents and 'Model' Biological Systems", Joint Chemical Institute of Canada-American Chemical Society Conference, Toronto, Canada, 28 May 70.

Capt Michael Ciletti	"N-Person Differential Games with Information Time Lag", 1970 Summer School on Mathematical Models of Action and Reaction, Ravenna, Italy, Jun 70.
Capt Michael D. Ciletti	"Differential Games - A Critical View", 1970 Joint Automatic Control Conference, Georgia Institute of Technology, Jun 70. Co-authored with Dr. Alan W. Starr
Capt David Finkleman	"Some Aspects of Radiating Flows About Pointed Bodies", 1970 Heat Transfer and Fluid Mechanics Institute, 10-12 Jun 70.
Capt Kenneth D. Senne Dr. B. B. Goode	"Adaptive Estimation in a Non-Stationary Environment", 1970 Intl Symposium on Information Theory, Noordwijk, The Netherlands, 15-19 Jun 70.
Capt Kenneth D. Senne Professor R. S. Bucy	"Digital Realization of Optimum Discrete-Time Nonlinear Estimators", 1970 Intl Symposium on Information Theory, Noordwijk, The Netherlands, 15-19 Jun 70.
Capt A. A. Fannin, Jr.	"Thermodynamic Properties of CF_4 - CH_4 in the Neighborhood of the Upper Critical Solution Temperature", 1970 Cryogenic Engineering Conference, Univ of Colorado, Boulder, Colorado, 18 Jun 70.
Capt Roger Gallington Capt David Finkleman	"Determination of Realistic Performance Trade-offs in the Air-to-Air Role", AIAA 2d Aircraft Design and Operations Meeting, 22 Jul 70.
Capt Roger Gallington 2d Lt Mark K. Miller	"The Ram-Wing: A Comparison of Simple One Dimensional Theory with Wind Tunnel and Free Flight Results", AIAA Guidance, Control and Flight Mechanics Meeting, Univ of Calif., Santa Barbara, 17-19 Aug 70.
Capt Kenneth D. Senne	"Realization of Optimum Discrete-Time Nonlinear Estimators", Symposium on Nonlinear Estimation Theory and Its Applications, San Diego, 21-23 Sep 70.
Capt David Finkleman	"Nonequilibrium Radiative Gasdynamics of Pointed Bodies", 21st Intl Astronautical Congress, Federal Republic of Germany, Konstanz, 3-10 Oct 70.
Capt Dino A. Lorenzini	"An Improved Gyro Error Model", 5th Guidance Test Symposium, Holloman AFB, NM, 14 Oct 70.

Lt Col Lowell A. King
Maj David W. Seegmiller

"An Aluminum Chloride Concentration Cell",
Southeast-Southwest Combined Regional
Meeting of the ACS Meeting, New Orleans,
La., 2-4 Dec 70 (Industrial Chemistry Div.)

Lt Col Lowell A. King
Maj David W. Seegmiller

"Liquid and Vapor Densities of Aluminum
Chloride", Southeast-Southwest Combined
Regional Meeting of the ACS, New Orleans,
La., 2-4 Dec 70 (Physical Chemistry Div.)

Capt Michael D. Ciletti

"Some New Results in the Theory of Differ-
ential Games with Information Time Lag",
Fourth Intl Conference on System Sciences,
Univ of Hawaii, Honolulu, 12 Jan 71.

Capt Kenneth D. Senne

"A Unified Theory of Adaptive Estimation",
Fourth Intl Conference on System Sciences,
Univ of Hawaii, Honolulu, 12 Jan 71.

Capt David Finkleman

"New Interpretations of Normal Shock Wave
Structure in Radiating Gases", NASA Symposium
on Hypervelocity Radiating Flow Fields for
Earth and Planetary Entries, Langley Research
Center, Hampton, Virginia., 22-23 Jan 71.

Capt David Finkleman

"Nonlinear Vortex Interactions on Wing-
Canard Configurations", AIAA 9th Aerospace
Sciences Meeting, New York, 25-27 Jan 71.

Maj David W. Seegmiller
Capt David S. Olson
Capt A. A. Fannin, Jr.

"Some Physical Properties of Aluminum
Chloride Melts," 42d Annual Meeting of the
Colorado-Wyoming Academy of Science,
Southern Colorado State College, Pueblo,
Colo., 30 Apr 71.

Capt A. A. Fannin, Jr.
Lt Col Lowell A. King
Maj David W. Seegmiller

"A Model for Aluminum Chloride-Sodium
Chloride Melts", 42d Annual Meeting of the
Colorado-Wyoming Academy of Science, Southern
Colorado State College, Pueblo, Colo., 30 Apr
71.

INVITED SEMINARS

- Lt Col Bernard S. Morgan, Jr. "Topics in Control Theory", Washington University, St. Louis, Missouri, 5-6 Apr 66.
- Capt Roger A. Geesey "Signal Detection Problems", Institute for Defense Analysis, 9 Aug 66.
- Lt Jon M. Veigel "The Acid-Catalyzed Aqueous Reaction of Cis-oxalato-triethylenetetramine-chromium(III) Cation", University College, London, England; Imperial College, London, England; University of St. Andrews, St. Andrews, Scotland; Oct 66.
- Capt Charles F. Stebbins "Experiments on Ionizing MHD Shock-waves", University of Colorado, 1 Nov 66.
- Lt Gerald Cook "Control Systems Study of the Human Eye Movement Mechanism", Sigma Xi Luncheon, Colorado State University, 9 Dec 66.
- Capt Roger Geesey "The Pseudo-inverse of a Linear Operator Described by a Dynamical System", Stanford Electronics Lab, 13 Dec 66.
- Lt Col Bernard S. Morgan, Jr. "Sensitivity of Multivariable Systems", University of Denver, 27 Jan 67.
- Capt John F. Schaefer "Some Problems Associated with the Control and Controllability of an Unstable System", University of Minnesota, 18 Apr 67; Rensselaer Polytechnic Institute, 20 Apr 67; and AFIT short course on Guidance and Control, AFIT, Wright-Patterson AFB, Ohio, 21 Apr 67.
- Lt Ralph W. Rudolph "Stereochemical Investigation: The NMR Spectra of P_2F_4 and the Mechanism of B_2Cl_4 Addition to Unsaturated Organic Compounds", University of Michigan, 7 Sep 67.
- Lt Col Bernard S. Morgan, Jr. and Maj R.F. Vachino "Optimal Evasive Maneuvers for an Engagement Between an Aircraft and Beam Rider Missile", State University of New York, Stony Brook, 14 Sep 67.

Capt John F. Schaefer	"Chattering Theory", State University of New York, Stony Brook, 14 Sep 67.
Lt Col Bernard S. Morgan, Jr.	"Pursuit and Stabilization", US Army Weapons Command Colloquium, Rock Island Arsenal, Illinois, 2 Oct 67.
Maj Lowell A. King	"High Energy Density Electrochemical Cells", Universidad Catolica del Peru, Lima, Peru, 2 Oct 67; Universidad de Chile, Santiago, Chile, 4 Oct 67; Universidad Nacional de Cordoba, 7 Oct 67; Universidad Nacional de Buenos Aires, 10 Oct 67; Universidad Nacional de la Plata, 10 Oct 67.
Lt Jon M. Veigel	"Acid Catalyzed Aqutation of α -Cr(trien) (C_2O_4) ⁺ ", Monsanto Chemical Company, Central Research, St Louis, Missouri, 14 Dec 67; University of New Mexico, Albuquerque, New Mixico, 18 Dec 67; San Diego State College, 8 Jan 68; Fresno State College, 10 Jan 68.
Capt Dirk H. deDoes and Lt Col Bernard S. Morgan, Jr.	"Computer Optimization Study of a Tactical Aircraft-Missile Engagement", Douglas Missile and Space Division, 8 Jan 68; North American Science Center, 9 Jan 68.
Capt John F. Schaefer	"Some Broom-Balancing Results", University of Denver, 9 Feb 68.
Lt Ralph W. Rudolph	"Difluorophosphine Ligands", University of Utah, 21 Feb 68.
Maj Lowell A. King	"Chemistry in South America - An Illustrated Trip Report", Colorado College, 26 Feb 68.
Lt Jon M. Veigel	"Acid Catalyzed Aqutation of α -Cr(trien) (C_2O_4) ⁺ ", Claremont Colleges, Calif., 14 Mar 68.
Maj Lowell A. King	"Electrochemistry of Aluminum Anodes in Molten Electrolytes", AF Cambridge Research Laboratories, 3 May 68.
Capt Roger W. Gallington	"Research Opportunities for Junior Officers in OAR", California Institute of Technology, California, 5 Jun 68.

Capt George J. Gauthier	"Some Chemistry of Metallocenes", Arapahoe Chemical Company, Boulder, Colorado, 19 Sep 68.
Lt Col Bernard S. Morgan, Jr.	"Optimization Techniques Applied to Pursuit and Evasion Problems", Washington University, St. Louis, Missouri, 1 Oct 68.
Lt Michael D. Ciletti	"Differential Games", US Army Weapons Command Colloquium, Rock Island Arsenal, Illinois, 30 Sep 68; Washington University, St. Louis, Missouri, 1 Oct 68.
Capt Ralph W. Rudolph	"Difluorosphine Ligands", University of Illinois, Champaign-Urbana, Illinois, 3 Oct 68; Purdue University, Indiana, 4 Oct 68; Massachusetts Institute of Technology, 21 Nov 68; and University of Michigan, Ann Arbor, Michigan, 25 Oct 68.
Capt Dirk H. deDoes, Lt Michael D. Ciletti, and Lt Col Bernard S. Morgan, Jr.	"Optimal Control and Differential Games Applied to the Pursuit-Evasion Problem", AFIT Short Course in Guidance and Control for Aerospace Vehicles, Wright-Patterson AFB, Ohio, 22 Apr 69.
Capt David Finkleman	"Radiative Gas Dynamics", University of Colorado, Boulder, Colorado, May 69.
Major Roger Geesey	"Applications of the Canonical Representation to Estimation and Detection", Washington Univ., St. Louis, Mo., Jul 69
Lt Robert E. Cochoy	"Synthesis and Electrophilic Reactions of Cyclopropanols", Colorado College, 5 Dec 69.
Capt David Finkleman	"Vortex Interactions in Modern Aerodynamics", Oklahoma State Univ., 2 Mar 70.
Maj A. D. Brown, Jr.	"Chemistry of Ferrocenophanes", Colorado College, 11 Mar 70.
Capt David Finkleman	"Wing-Canard Interactions on Slender Air- craft", Wichita State Univ., 22 Mar 70.
Maj A. D. Brown, Jr.	"Chemistry of Ferrocenophanes", Auburn University, 27 Mar 70.
Capt David Finkleman	"Vortex Interactions in Modern Aerodynamics", Univ of Oklahoma, 3 Apr 70.

Lt Col Lowell A. King

"The Structure of Aluminum Chloride-Sodium Chloride Melts", Colorado State Univ., Ft. Collins, Colo., 20 Apr 71.

Lt Col Lowell A. King

"The Structure of Aluminum Chloride-Sodium Chloride Melts", Univ of Tennessee, Knoxville, Tenn., 22 Apr 71.

Lt Col Lowell A. King

"The Structure of Aluminum Chloride-Sodium Chloride Melts", Oak Ridge National Laboratory, Oak Ridge, Tenn., 23 Apr 71.

SEMINARS SPONSORED BY FJSRL

INVITED SPEAKERS

Dr. P.M. Quinlan University College, Cork, Ireland	"The λ -method for Linear Boundary-Value Problems", 4 Jun 64.
Dr. J.J. Smolderen von Karman Institute for Fluid Dynamics, Brussels, Belgium	"Near Free-Molecular Behavior of Gases with Infinite Collision Cross-Sections", 23 Jul 64.
Dr. F.D. Faulkner US Naval Postgraduate School	"Topics in Optimization", 27-31 Jul 64.
Professor Latvi Zadeh University of California, Berkeley	"Learning, Abstraction, and Generalization Processes", 20 Aug 64.
Professor L. Moulin von Karman Institute for Fluid Dynamics, Brussels, Belgium	"Discussion of a Compromise between Rocket and Atmospheric Braking", 14 Sep 64.
Professor G.A. Korn University of Arizona	"Fast Analog-Hybrid Computation with Digital Control: The ASTRACT II System", 26 Oct 64.
Professor R.V. Gamkrelidze Academy of Sciences of USSR	"Extremal Problems in Differential Equations", 1 Dec 64.
Professor E.F. Mishchenko Academy of Sciences of USSR	"A Stochastic Problem in Optimal Control", 1 Dec 64.
Dr. Arthur L. Draper Texas Tech	"The Presence of Iron Oxide in the Surface of Mars, 20 Jan 65.
Professor H.C. Larsen Air Force Institute of Technology	"The Design and Operation of COIN Aircraft"
Dr. Carl R. Johnson Wayne State University	"Some Aspects of Stereochemistry in Natural Product Synthesis", 23 Jul 65.
Professor G. Leitmann University of California	"The Maximum Principle", 23-27 Aug 65.
Dr. Edward L. King University of Colorado	"Solvation of Chromium(III) Ion in Mixed Solvents", 30 Sep 65.
Dr. C.A. Angell Argonne National Laboratory	"The Structure and Transport in Ionic Liquids: The General Significance of the Glass Transition Phenomenon", 10 Jan 66.
Dr. Donald A. House UCLA	"Chemistry in the Antarctic", 17 Jan 66.

Dr. Donald A. House UCLA	"Synthesis of Some Novel Chromium Complexes", 19 Jan 66.
Dr. Henry E. Wirth Syracuse University	"Molal Volumes of Electrolytes in Mixed Solutions", 25 Jan 66.
Professor Hans Liepmann California Institute of Technology	"Research in Gas Dynamics", 27-28 Mar 66.
Mr. Occhini Olivetti-General Electric Milan, Italy	"Computers", 24 Mar 66.
Professor Larry Kevan University of Kansas	"Energy Transfer from Irradiated Rare Gases", 4 Apr 66.
Dr. Bruno Zwolinski Texas A and M University	"Non-Bonded Atom Interactions and Energies of Molecules", 22 Apr 66.
Capt Marfitt Nuclear Engineering Test Facility	"Facilities and Capabilities of Nuclear Test Facilities at Wright-Patterson", 29 Apr 66.
Dr. B. Paiewonsky Institute for Defense Analysis	"Optimal Control", 29 Apr 66.
Dr. T. Bullock Stanford University	"Direct Methods for Solution of Optimal Control Problems via Gradient Techniques Utilizing Second Variations", 16 May 66.
Dr. Leo Brewer University of California, Berkeley	"High-Temperature Molecules", 24 Jun 66.
Dr. David Goldsmith Emory University	"Approaches to the Synthesis of Terpenoids via Epoxy Olefin Cyclization", 18 Aug 66.
Dr. G. Olaf Larson University of Colorado	"Paper Stereomodels - A New Tool for Chemical Education", 30 Aug 66.
Dr. Robert H. McCluer The Ohio State University	"Glycolipids", 1 Sep 66.
Dr. Carl Kaplan Johns Hopkins University	"Oseen Flow" (given to a cadet class), Sep 66.
Colonel Leonard Carson Headquarters, OAR	"The Value of Being a Fighter Pilot to a Research and Development Career", Oct 66.
Mr. Karl Brammer DVL Institute for Guidance-Control, Germany	Lectures on Filtering Theory, Oct 66-Feb 67.

Capt Sydney Stewart USAF Academy Hospital	"Human Gammaglobulins in Health and Disease", 1 Nov 66.
Professor E. Gilbert University of Michigan	"Optimal Control", 7 Nov 66.
Dr. B. Palewosky Institute for Defense Analysis	Lectured to cadets in Astro 450 - Control Theory, 14-16 Nov 66.
Dr. Harold Rosenberg AF Materials Laboratory	"Current Research in Chemistry at Air Force Materials Laboratory", 13 Dec 66.
Dr. Amos Horney AFOSR	"Laboratory Reorientation", 13 Dec 66.
Dr. Jeremy L. Sprung Monsanto Chemical Company	"The Actions of Thermal Carbon with Benzene", 23 Dec 66.
Professor Stephen Kahne University of Minnesota	"State Variables", 20 Jan 67.
Professor Lawrence Young Massachusetts Inst. of Technology	"Man-Vehicle Control Systems", 27 Jan 67.
Dr. Jack Mitchell University of Virginia	"Survey of Electrochemical Areas of Air Force Interests", 27 Jan 67.
Professor A. Bryson Harvard University	"Applications of Optimal Control Theory in Aerospace Engineering", 2 Feb 67.
Dr. Paul E. Stanley Purdue University	"The Purdue Aero and Astro Program - Its Purpose and Direction in the Next 5-10 Years", 7 Mar 67.
Dr. Hans W. Liepmann California Institute of Technology	"Current Topics in Gas Dynamics", 23 Mar 67.
Dr. L.P. Quinn AF Rocket Propulsion Laboratory	"Molecular Orbital Theory and Application to Rocket Propulsion", 21 Apr 67.
Dr. Milton Van Dyke Stanford University	"How Are We Going to Solve Fluid Mechanics Problems in the Next Ten Years?", 27 Apr 67.
Dr. Robert Bass Douglas Aircraft Corporation	"Solution of Matrix Riccati Equation", 29 May 67.
Dr. George Leitmann University of California	"Differential Game", 15-16 Aug 67.
Dr. G.M. Kosolapoff Auburn University	"Chemical Education in the USSR", 15 Aug 67.

Mr. T. Edelbaum Analytical Mechanics Associates	"Minimum Fuel Rendezvous with Near Circular Orbits" and "Minimum Fuel Explicit Guidance for Injection for Circular Orbits", 11 Sep 67.
Dr. Joseph Earley Georgetown University	"Chromium Coordination Chemistry", 11 Sep 67.
Dr. Gordon Harris State University of New York, Buffalo, New York	"Reaction of $C_2O_4^{2-}$ with $Co(C_2O_4)_2(OH_2)_2$ ", Jul 67.
Lt Donald Kleist AFATL	"SAM Evasion Tactics", 26 Sep 67
Dr. M.F. Hawthorne University of California, Riverside	"Carboranes", 25 Oct 67.
Lt Donald Kleist AFATL	"SAM Evasion Tactics, Part II", 26 Oct 67.
Lt William Chase AFATL	"F4, MIG 21, F111 Energy Maneuverability", Oct 67.
Dr. Lee J. Todd University of Illinois	"Recent Advances in one-Carbon Carborane Chemistry", 6 Nov 67.
Dr. R. Korkegi ARL (OAR)	"Research in Hypersonic Aerodynamics", 22 Feb 68.
Dr. Harold P. Smith, Jr. University of California	"Implications of Vulnerability on Strategic Planning", 15 Mar 68.
Dr. Charles Bock AF Rocket Propulsion Lab	"X-Ray Diffraction and Fluorescence", 19 Mar 68.
Dr. Arlan Norman University of Colorado	"Some Recent Chemistry of Silicon and Phosphorus-Hydrides", 11 Apr 68.
Lt Col Hugo deOliveira Pira (Cal Tech and Brazilian AF)	"Density Measurements in the Reflecting Shock Using an Electron Beam", 31 Jul 68.
Capt Clair J. Cheer USAF Reserve, University of Rhode Island	"X-Ray Crystallography", 1 Aug 68.
Major E. Volgenau Office of the Secretary of Defense	"On the Organization and Function of the OSD", 20 Aug 68.
Maj L.A. King and Maj D.W. Seegmiller (DFC, USAF Academy)	"TDY to Southeast Asia", 27 Aug, 26 Sep 68.
Lt George Rhodes DFC, USAF Academy	"Some Aspects of Molecular Orbital Theory as Applied to Photooxidation Reactions", 3 Sep 68.

Professor Daniel Bershader
Stanford University

"On Results of an Interferometric Study of the Nonequilibrium Shock Reflection Process and Thermal Layer in Ionizing Argon", 11 Oct 68.

Maj Robert W. Lamb
DFC, USAF Academy

"Scientific Potential of India", 14 Nov 68.

Dr. Tapan K. Mukherjee
AF Cambridge Research Laboratories

"The Reactivities of Electron Acceptor Molecules", 10 Dec 68.

Dr. Harold Rosenberg
AF Materials Laboratory

"Recent Advances in Polymer and Related Chemistry".

Dr. John Birmingham
Arapahoe Chemical Company

"Recent Developments in Homogeneous Catalysis and Some Aspects of Process Developments", 27 Jan 69.

Dr. Bernard Paiewonsky
Institute for Defense Analysis

"Energy Maneuverability", 12 Feb 69.

Maj G.D. Brabson
DFC, USAF Academy

"The Color of Minerals", 13 Feb 69.

Dr. I.M. Kolthoff
University of Minnesota

"Acid-Base Equilibrium in Aprotic Solvents", 17 Feb 69.

Dr. Robin Harris
Visiting Scientist, University of Utah

"NMR of Phosphorus-containing Compounds", 18 Feb 69.

Dr. Charles U. Pittman
University of Alabama

"Recent Developments in Carbonium Ion Chemistry", 3 Apr 69.

Professor John Nicolaides
University of Notre Dame

"Research on Ballistics of Bombs and on the Parafoil", 13 May 69.

Col P. G. Atkinson, Jr.
HQ AFSC (SCT) and
Major J. W. Silvis
ORA (RRRC)

"Thrust Augmentation Research, 9 Sep 69.

1Lt Michael Freeburger
ARL, WPAFB, Ohio

"Synthesis of Thermally Stable Polymers", 30 Sep 69.

Dr. Thomas O. Tiernan
ARL, WPAFB, Ohio

"Studies of Ionic Chemistry in the Gas Phase by Mass Spectrometric Methods", 23 Oct 69

Major Duncan E. Dodds
AFATL, Eglin AFB, Fla.

"Current Research in Explosives",
13 Nov 69

Dr. R. M. Izatt
Department of Chemistry, BYU

"Chemistry of Metal-Cyclic Polyether
Complexes", 14Nov69.

Professor Angelo Miele
Rice University

"A New Gradient Algorithm for the Minimization of Functionals", 14 Nov 69.

Dr. Roger N. Kust
University of Utah

"Acid-base Reactions in Molten Salt
Solvents", 20 Nov 69.

Mr. Hal Cornish and
Mr. E. J. Heesacker
Thiokol Corp.

"Analysis of Short Range Missile with
Thrust Vector Control", 5 Dec 69.

Dr. Eric Allen
National Center for Atmospheric
Research
Boulder, Colorado

"Atmospheric Photochemistry", 15 Jan 70

Dr. Peter Dorato
University of Colorado

"Optimal Steady State Control of Deterministic
Finite State Machines", 16 Apr 70.

Dr. Bernard Paiewonsky
Institute for Defense Analysis

"Aircraft Performance Analysis", 15 May 70.

Dr. Michael Athans
Massachusetts Institute of
Technology

"Adaptive Stochastic Control for Linear
Systems with Unknown Parameters" and
"Design of Linear Dynamic Compensators with
Constrained Dimension", 25 May 70.

Mr. Howard L. Conkey
Ryan Aeronautical Division
of Teledyne

"Remotely Manned Systems", 24 Aug 70.

Capt Robert E. Cochoy
FJSRL (NC)

"The Synthesis and Reactions of Cyclopropanols"
10 Sep 70.

Dr. Victor Linder
Picatinny Arsenal

"Air Force Needs in Ammunition and
Explosives", 11 Sep 70.

Dr. Mortimer J. Kamlet
US Naval Ordnance Laboratory
White Oak, Silver Spring, Md.

"Structure-Property Relationships as a
Guide Toward New Explosives Synthesis",
22 Sep 70.

Dr. Horst G. Adolph
US Naval Ordnance Laboratory
White Oak, Silver Spring, Md.

"Intermediates in Fluoronitroaliphatic
Chemistry", 22 Sep 70.

Dr. M. J. Zabik
Pesticide Research Center
Michigan State University

"Movement of Pesticides in the
Environment", 7 Oct 70.

Dr. Allen Schoffstall
University of Colorado
Colorado Springs Center

"Design and Synthesis of Potential
Anti-Cancer Agents Related to Guanine",
20 Jan 71.

Dr. Isaac Horowitz
Weizmann Institute of
Science, Israel

"Topics in Adaptive Control", 5 Feb 71.

Dr. Gerald Karr
University of Illinois

"Satellite Drag", 7 Apr 71.

Mr. Harold Garrett
AFML, Wright-Patterson AFB OH

"Rare Earth Permanent Magnets", 12 Apr 71.

Capt Deborah J. Griest
ARL, Wright-Patterson AFB OH

"Lunar Rock Analyses", 29 Apr 71

Mr. Stanley Liberty
Notre Dame University

"New Results in Stochastic Control Theory",
6 May 71.

ORGANIZATION AND MANNING

FRANK J. SEILER RESEARCH LABORATORY

Professional Manning

<u>Name</u>	<u>Grade</u>	<u>Degree</u>	<u>AFSC</u>	<u>Date Arrived</u>
<u>COMMAND</u>				
Milton D. Sprinkel	Col	M.S.	2716	Jul 69
Harold Beck	LtCol	M.A.	2616	Jul 67
<u>DIRECTORATE OF CHEMICAL SCIENCES</u>				
Jack A. Winstead	LtCol	Ph.D.	2716	Jun 68
G. Dana Brabson	Maj	Ph.D.	2716	Jan 71
F. Warren Villaescusa	Maj	Ph.D.	2645C	Jul 71
Armand A. Fannin, Jr.	Capt	M.S.	2645D	May 70
Raymond McGuire	Capt	Ph.D.	2645C	Sep 69
John G. Breland Jr.	Capt	Ph.D.	2645C	Sep 71
Robert E. Cochoy	Capt	Ph.D.	2645C	Feb 69
Donald D. Potter	Capt	B.A.	2645C	Feb 71
Hans Reich	GS-11	Ph.D.	2645C	Sep 64
J. Lloyd Pflug	GS-11	M.S.	2645A	Nov 64
<u>DIRECTORATE OF AEROSPACE-MECHANICS SCIENCES</u>				
John Paul Hyde	LtCol	Ph.D.	2716	Jun 69
George R. Hennig	Maj	Ph.D.	2716	Sep 68
Brock T. Strom	Maj	Ph.D.	2845E	Sep 71
Dino A. Lorenzini	Capt	Sc.D.	2845D	Feb 70
Donald K. Bissonnette	Capt	M.A.	5125C	Jun 70
Gary C. Comfort	Capt	Ph.D.	2845D	Jun 70
David Finkleman	Capt	Ph.D.	2855B	Oct 67
Michael D. Ciletti	Capt	Ph.D.	2845D	Feb 68
Kenneth D. Senne	Capt	Ph.D.	2825C	Sep 68
Robert A. Golobic	1Lt	Ph.D.	2855B	Feb 71

DIRECTOR OF LABORATORIES, AFSC

FRANK J. SEILER RESEARCH LABORATORY

Col	Commander	2716
GS-6	Secretary	70450

DIRECTORATE OF
AEROSPACE-MECHANICS SCIENCES

Lt Col	Director	2716
Lt Col	Deputy Director	2716
Capt	Astro Rsch Engr	2845D
Capt	Astro Rsch Engr	2845D
Capt	Elect Rsch Engr	2825C
Capt	Aero Rsch Engr	2855B
Capt	Aero Rsch Engr	2855B
Capt	Compt Sys Des Engr	5125C
Lt	Astro Rsch Engr	2845D
GS-11	Elect Engr	2825C
GS-9	Mech Engr Tech	53150
SSgt	Instr Tech	31750
SSgt	Instr Tech	31750
GS-5	Secretary	70450
GS-4	Clerk-Steno	70450

DEPUTY PLANS AND PROGRAMS

Lt Col	Dep Plans & Prog	2616
MSgt	Adm Sup	70270
TSgt	Inv Mgmt Spec	64570

DIRECTORATE OF
CHEMICAL SCIENCES

Lt Col	Director	2716
Lt Col	Deputy Director	2716
Maj	Rsch Chem Org	2645C
Capt	Rsch Chem Phys	2645C
Capt	Rsch Chem Phys	2645D
Capt	Rsch Chem Org	2645C
Lt	Rsch Chem Org	2645C
GS-11	Chemist	2645A
GS-11	Chemist	2645C
GS-5	Phys Science Aide	99127
GS-5	Secretary	70450

B I O G R A P H I E S

Colonel Milton D. Sprinkel

Colonel Milton D. Sprinkel assumed command of the Frank J. Seiler Research Laboratory during August 1969. He had just completed a tour as Commander of the Office of Research Analyses (ORA) at Holloman AFB, New Mexico, which had the responsibility for conducting: Mission analyses to identify future aerospace missions; systems analyses to determine technical validity, operational feasibility, and cost-effectiveness of future aerospace systems; and research analyses to identify promising opportunities for relevant research programs. He served in this capacity from January 1967.

Colonel Sprinkel was born 8 December 1920 in Binger, Oklahoma. He received his BS degree in Chemical Engineering from Oklahoma A&M College in 1943, and an MS degree in Chemical Engineering from Purdue University in 1949. During World War II, he served as a B-24 aircraft commander with the 14th Air Force in China and with the 5th Air Force in Okinawa. In July 1946, Colonel Sprinkel accepted a regular commission and was assigned to the Army Chemical Corps, Edgewood Arsenal, Maryland, until April 1947. He was then transferred to the Air Proving Ground, and during this assignment, attended the Air Tactical School (now Squadron Officers Course) at Tyndall Field, Florida.

In June 1948, Colonel Sprinkel was assigned to Purdue University and graduated in August 1949 with a Master of Science degree in Chemical Engineering. Following his graduation, he was assigned to the Los Alamos Scientific Laboratory where he conducted research on nuclear weapons components and later participated in atomic weapons testing at Eniwetok Atoll in the Pacific. In 1953, Colonel Sprinkel was transferred to the Air Force Special Weapons Center at Kirtland AFB where he worked closely with the Sandia Corp., Los Alamos Scientific Laboratory, and Livermore Radiation Laboratory on programs associated with the design, handling, and delivery of nuclear weapons.

From July 1956 to June 1959, Colonel Sprinkel was assigned to the European Office of ARDC in Brussels, Belgium, where he had responsibility for the Air Force program of basic research in chemistry being supported at a large number of European universities. Following this overseas assignment, Colonel Sprinkel was Associate Professor and Deputy Head of the Department of Chemistry at the US Air Force Academy, Colorado, from 1959 to 1963. He served as a staff scientist with the Directorate of Chemical Sciences, Air Force Office of Scientific Research (AFOSR), from 1963 to December 1965, and became Assistant Executive Director, Research Communication, AFOSR, in December 1965.

Colonel Sprinkel is a member of the American Chemical Society, Research Society of America, and Phi Kappa Phi. He is listed in American Men of Science.

Colonel Sprinkel is married to the former Nelda L. Davis of Anadarko, Oklahoma. They have two sons: Stanley and Lt David M. Sprinkel of the United States Air Force.

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Lt Colonel Harold Beck

Lt Col Beck was assigned to FJSRL in July 1967 as Programs-Executive. His duties include plans, budgets, forecasting of financial requirements, personnel, security and executive officer responsibilities. He provides the Deputy Commander function in the absence of the Commander.

Lt Col Beck was born 19 March 1919 in Brooklyn, NY. He received a B.A. in Mathematics from Brooklyn College in June 1941. He attended UCLA between 1943 and 1963 part and full time for an aggregate of 4 1/2 years of post graduate studies. He was awarded an M.A. in Mathematics in June 1955. Lt Col Beck's minors were in Physics, Economics, and Education. His current status at UCLA is a candidate for Ph.D. in Education Administration.

Lt Col Beck enlisted as an Aviation Cadet in June 1942. His first commissioned assignment was to the 10th Photo Recon Sq at Peterson Field, Colorado Springs. He was given a years graduate study in Meteorology at UCLA in 1943. He was assigned to the 25th Weather Sq at detachments in Manchester, N.H. and Richmond, Va.

Lt Col Beck's WWII overseas assignments were with the Air Transport Command in Samoa and Hawaii. He was assigned to the 88th Air Depot Wing (Reserve) in Santa Monica, California between Jan 1946 and April 1951 as a Statistician. His civilian position during this period was senior Financial Manager for the Los Angeles Board of Education.

Lt Col Beck was recalled to active duty in April 1951 as the Chief of the Prog and Anal Office SBAMA, Norton AFB, Calif. In Sep 1953 he was assigned to UCLA, under AFIT, as a graduate student in Linear Programming and Computer System Design. In June 1955 he was assigned as the Chief of the Mgt Science Br, Comp Div, Dir of Mgt Anal, Hq USAF. During this assignment he designed the first large scale computer management application in the USAF. The system, part of the programming-budgeting cycle, is still in use today at Hq USAF.

In June 1959 Lt Col Beck was assigned to AFBMD in Los Angeles as the Chief of the Oper Resh Office. He developed computer management applications for the newly emerging missile and space program. He was instrumental in introducing the PERT Management Technique for use by the System Program Offices that were developing the USAF missile and space systems.

In April 1963 Lt Col Beck was called back to the Pentagon as Asst Chief of the Info Processing and Display Div of the Joint Command and Control Requirements Group under the Joint Chiefs of Staff to assist in the development of the World Wide Military Command and Control System.

Lt Col Beck was married in November 1941 to the former Sadie Marder of Brooklyn, New York. They have three children: Peter, a SAC Capt stationed at McConnell AFB; William, a graduate student at California State College at Long Beach; and Jeanne, a student at Air Academy High School. The Beck's permanent home is in Los Angeles, California.

Lt Colonel John Paul Hyde

Lt Colonel John Paul Hyde reported to duty as the Director of Aerospace-Mechanics Sciences, FJSRL, in June of 1969.

Lt Col Hyde was born 21 July 1934 in Cincinnati, Ohio. He received a bachelor's degree in Electrical Engineering from the University of Cincinnati in 1957 and, through the AFROTC, a commission in the US Air Force. Later, he attended the University of Pittsburgh, Pennsylvania, under the Air Force Institute of Technology program, and was awarded M.S. and Ph.D. degrees, both in Electrical Engineering. His research concerned switching feedback control systems.

Lt Col Hyde was called to active duty with the USAF in 1958. He was assigned to Headquarters, Washington Air Defense Sector (SAGE), Fort Lee, Virginia (now the 33rd Air Division) from 1959 to 1962 where he served as Radio and Wire Communications Staff Officer.

He was attached to the Air Force Technical Applications Center, Alexandria, Virginia, from 1965 to 1968. He served there as a project officer in the DOD (Advanced Research Projects Agency) VELA-UNIFORM Research and Development Program to develop improved seismic methods for detecting underground nuclear explosions, supervising seismic-instrumentation development projects. He was also Acting Chief, Special Projects Branch of the VELA Seismological Center.

Lt Col Hyde is a graduate of the USAF Squadron Officer School, Class 61-C, a Distinguished Graduate of the Air Command and Staff College, Class of 1969, and is a graduate of the Harvard Business School's Program for Management Development, Class 19, 1970. He is a member of Eta Kappa Nu, Tau Beta Pi, and an Assistant Professor of Astronautics, USAF Academy. He is the author of several papers on digital controllers and switching feedback control systems.

His wife is the former Elizabeth Twyman of Dayton, Ohio. They have two children: Clinton and Paula.

Lt Colonel Jack A. Winstead

Lt Colonel Jack A. Winstead was assigned as Director, Directorate of Chemical Sciences, Frank J. Seiler Research Laboratory, in May 1970. He previously served as a Research Associate, coming to FJSRL in June 1968.

Lt Colonel Winstead was born 13 June 1932 in Dixon, Kentucky, and was graduated from Dixon High School in 1950. He received a BS degree in Agriculture in June 1954 from the University of Kentucky and as an AFROTC graduate was commissioned in the Air National Guard. Lt Colonel Winstead's initial duty assignment was to the Materials Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio, where he served as a Project Officer from November 1954 to August 1957. He conducted research on gas analyses of metals and spectroscopic procedures. In 1955 he was transferred from the Air National Guard to the United States Air Force.

He entered Oklahoma State University in September 1957 under the AFIT Program, and received the MS degree in Chemistry in May 1959. He served as an Instructor in the Department of Chemistry, USAF Academy, from 1959-1961 and as an Assistant Professor from 1961-1962.

In June 1962, Lt Colonel Winstead entered the University of Illinois under the AFIT Program, and received the PhD degree in Chemistry in June 1964. He was then assigned to the Radiobiology Division of the School of Aerospace Medicine. As a Task Scientist, he conducted research in radiobiology and radiation biochemistry and monitored a number of research contracts in radiobiology. The Air Force Outstanding Unit Award Ribbon was received by Lt Colonel Winstead during this assignment.

Lt Colonel Winstead is a member of Phi Lambda Upsilon, Sigma Xi, Radiation Research Society, American Association for the Advancement of Science and the American Chemical Society. He is author or co-author of a number of scientific papers in biochemistry, radiation biochemistry and organic chemistry.

He is married to the former Mary Anne Purdy of Paducah, Kentucky. They have three daughters: Karen, Katherine and Sheri.

Major George R. Hennig

Major George R. Hennig reported to the Frank J. Seiler Research Laboratory in September 1968 for duty as a Research Associate in the Directorate of Aerospace-Mechanics Sciences. He was designated Deputy Director on 1 Jul 1971.

Major Hennig was born 15 February 1935 in Hempstead, New York. He attended grade school and high school in both Hempstead and Garden City, New York. He graduated from high school in 1953 and attended the University of Michigan for one year prior to entering the United States Naval Academy. On 4 June 1958 he was graduated from the Naval Academy and received his commission in the United States Air Force.

Following schooling at Keesler AFB, Mississippi, Major Hennig was assigned in May 1959 as an Assistant Radar Maintenance Officer with the 728th Aircraft Control and Warning Squadron, TAC, Shaw AFB, South Carolina.

In August 1961, he was assigned to AFIT, resident school, where he obtained his M.S. degree in Astronautics. While at AFIT, he became a member of Tau Beta Pi.

In September 1963, he was assigned to Space Systems Division (AFSC), Los Angeles, California. He was assigned to 706 Program Office, Deputy for Technology, as a Project Officer/System Analysis. His duty included technical evaluation of contractor work on classified space vehicles. In May 1964, Major Hennig joined the START Program Office, Deputy for Technology, as a Project Officer/Vehicle Integration. This duty included the technical evaluation and direction of contractor work on the design, development and manufacturing of the PRIME lifting re-entry vehicle.

In May 1966, Major Hennig was again assigned to AFIT, resident school. He was awarded the PhD degree in Aerospace Engineering in June 1971.

Major Hennig was married to the former Marjorie D. Dobson of Seaford, Delaware, on 7 June 1958. They have two children: George Dixon and Diane Lynne.

Major G. Dana Brabson, Jr.

Major G. Dana Brabson was assigned as Deputy Director, Directorate of Chemical Sciences, Frank J. Seiler Research Laboratory, in January 1971.

Major Brabson was born 18 February 1935 in Washington, D.C., and graduated from Deerfield Academy, Deerfield, Massachusetts, in 1952. He received his BS degree in Chemical Engineering from Case Institute of Technology in 1956, and was commissioned in the Air Force upon completion of the AFROTC Program at that school.

His initial assignment was to the Field Command, Defense Atomic Support Agency, where he served as liaison officer and worked on those aspects of weapon system design which contribute to their safety.

He entered the University of California, Berkeley, in 1961 and received his MS degree in Chemistry the following year. During the academic year 1962-63, he was an Instructor of Chemistry at the USAF Academy. He returned to Berkeley in 1963 and received his PhD in Chemistry in 1965. His research was in the field of optical spectroscopy of high temperature molecules isolated in frozen inert gas matrices.

In 1965 he returned to the Department of Chemistry, USAF Academy, and served as Assistant Professor and then Associate Professor until 1970. His assignment immediately prior to the present one was as a student at the Armed Forces Staff College.

Major Brabson is a member of the American Chemical Society, The American Physical Society, The Colorado-Wyoming Academy of Science, Tau Beta Pi, and Sigma Xi. He has authored several papers both on spectroscopy of high temperature molecules and on techniques for teaching instrumental analysis at the undergraduate level.

He is married to the former Shirley Jean Stebbins of Fairmont, Oklahoma. They have three children : Jennifer, Robert and Andrew.

Major F. Warren Villaescusa

Major F. Warren Villaescusa will be assigned to the Frank J. Seiler Research Laboratory as a research chemist in the Directorate of Chemical Sciences in July 1971. Major Villaescusa will occupy the position in the Directorate reserved for one year tours for members of the USAF Academy faculty. He will return to the faculty in July 1972.

Major Villaescusa was born on 12 June 1938 at Fort Lewis, Washington, and graduated from Anne Arundel High School, Gambrills, Maryland, in 1956. He attended Washington State University and in 1961 graduated with a BS in Chemical Engineering. Having completed the AFROTC Program he was commissioned a Second Lieutenant in the Air Force.

His initial active duty assignment was with AFIT at Washington State University where he was awarded an MS in Organic Chemistry in 1963. From then until 1966 he was a project engineer at the AF Rocket Propulsion Laboratory, Edwards AFB, California, involved in formulating and test firing experimental solid propellants. From 1966 to 1968 he was on the Faculty of the Chemistry Department, USAF Academy. The following two years he attended graduate school at Arizona State University under a second AFIT assignment and was awarded a PhD in Organic Chemistry in 1971. In 1970 he returned to the Faculty of the USAF Academy.

Major Villaescusa is a member of the American Chemical Society and Sigma Xi.

He is married to the former Jo Anne Carlson. They have one son, Douglas, and two daughters, Kristina and Heather.

Major Brock T. Strom

Major Brock T. Strom will report to the Frank J. Seiler Research Laboratory in September 1971 for duty as a Research Associate in the Directorate of Aerospace-Mechanics Sciences.

Major Strom was born 21 September 1934 in Munising, Michigan. He attended grade school and high school in both Munising and Ironwood, Michigan. He graduated from high school in 1952 and attended Indiana University for three years where he majored in geology. He entered the initial class of the United States Air Force Academy in 1955. During the 1958 Academy football season, he was Captain of the undefeated Falcon football team which tied TCU in the Cotton Bowl. He was also selected as a Consensus All-American Tackle. He graduated in 1959 as a distinguished cadet and won the Goddard Award given to the outstanding cadet in mathematics. He also received the Superintendent's Award given to "the athlete who contributed most to the intercollegiate program".

His first assignment was to attend Massachusetts Institute of Technology. He graduated June 1961 with a Master of Science degree in Aeronautics and Astronautics. He then served as an Astronautical Engineer at the Air Force Missile Development Center, Holloman AFB, New Mexico, where he received the Air Force Commendation Medal for developing gyroscope test procedures.

He then served as a navigator on a C-130 in the 6593rd Test Squadron, Hickam AFB, Hawaii, and as a navigator on an EC-47 in the 361st Tactical Electronic Warfare Squadron, Nha Trang Air Base, Vietnam. He received the Air Medal with two Oak Leaf Clusters and the Distinguished Flying Cross while in Vietnam. His next assignment was as a War Plans Officer, Headquarters, Seventh Air Force, Tan Son Nhut Air Base, Vietnam. He received the Bronze Star Medal for developing an evaluation plan of an interdiction campaign which utilized unique equipment.

He entered Arizona State University in June 1969 under the AFIT Program. He expects to graduate in September 1971 with a PhD in Engineering Mechanics. The title of his dissertation was "Vibrations of Plane Curved Beams."

He is married to the former Claire Grosdidier of Kansas City and has three sons, Brock II, David, Christopher, and a daughter, Leigh Ann.

Captain Dino A. Lorenzini

Capt Dino A. Lorenzini reported to FJSRL for duty as Research Associate in the Directorate of Aerospace-Mechanics Sciences in February 1970.

Capt Lorenzini was born on 31 May 1940 in Kingston, Pennsylvania, and attended public school in Exeter, Pennsylvania. After graduating from Exeter High School in 1958, he entered the U.S. Air Force Academy. As a distinguished graduate of the fourth graduating class from the Academy, Capt Lorenzini went on to pursue a Master of Science degree in Aeronautics and Astronautics at the Massachusetts Institute of Technology.

In 1964, he was assigned to the Directorate for Guidance Test at the Air Force Missile Development Center, Holloman AFB, New Mexico. As a development engineer in the Gyroscope Test Branch, Capt Lorenzini developed test and analysis procedures for determining the performance of strapdown gyroscopes and inertial guidance systems. As a result of his research activity, he was awarded the 1966 Air Force Research and Development Award.

Also awarded the Air Force Commendation Medal for outstanding service, Capt Lorenzini returned to MIT in 1967. He received a Doctor of Science degree in Astronautics in 1970. His dissertation is titled "Gyro Error Modeling." Capt Lorenzini is a member of the American Institute of Aeronautics and Astronautics, the Society of Sigma Xi, the Institute of Navigation, and the Measurement and Data Society.

Capt Lorenzini is married to the former Lucille Vincenti of West Pittston, Pennsylvania. They have three sons: Edward, Dino and Michel.

Captain Donald K. Bissonnette

Capt Donald K. Bissonnette was assigned to the Directorate of Aerospace-Mechanics Sciences as a Computer System Design Engineer (Mathematics shredout) on 1 July 1971.

Capt Bissonnette was born on 17 March 1933 in Hartford, Connecticut, and attended public schools in West Hartford. He received a Bachelor of Arts degree, in English Literature from Trinity College, Hartford, Connecticut, in 1954, and taught high school mathematics in Connecticut for two years prior to entry on active duty.

In May 1956, he enlisted in the Air Force. He attended the Army Language School in California, where he studied the Czech language, and served three years with Air Force Security Service in Germany. Upon returning from Germany he attended Florida State University under the Airman Education and Commissioning Program, earning a Bachelor of Science degree in Mathematics in 1962.

Upon receiving his commission at OTS in December 1962, Capt Bissonnette attended the Computer Maintenance Officers Course at Keesler AFB, Mississippi. He then spent four years with Security Service at the National Security Agency where he directed a computer diagnostic maintenance programming group. In 1963 he was commissioned in the Regular Air Force.

In 1968 he entered the AF11 program and attended the University of Arizona, where he was awarded the degree of Master of Arts in Mathematics in 1970. Assigned to the Directorate of Computer Sciences at the Frank J. Seiler Research Laboratory in June 1970, he worked as a Mathematician/Programmer until his present assignment.

Capt Bissonnette is a member of the American Mathematical Society, the Mathematical Association of America, the Association for Computing Machinery, and the Air Force Association.

Captain Gary C. Comfort

Capt Gary C. Comfort reported to the Frank J. Seiler Research Laboratory in June 1970, as a Research Associate in the Directorate of Aerospace-Mechanics Sciences.

Capt Comfort graduated with distinction from the US Naval Academy in 1963. He attended the Massachusetts Institute of Technology for one year after Annapolis, and received the degree of Master of Science in Aeronautics and Astronautics.

From 1964 to 1967, Capt Comfort was assigned as an analyst to the Directorate of Foreign Technology, AF Missile Development Center, Holloman AFB, New Mexico. He is also a distinguished graduate of Squadron Officer's School.

Capt Comfort was awarded the degree of Doctor of Philosophy by the Massachusetts Institute of Technology in June 1971.

Capt Comfort and his wife, Jené, have two children, Gary Jr and Kim. Their permanent home is Alamogordo, New Mexico.

Captain Armand A. Fannin, Jr.

Captain Armand A. Fannin, Jr., was assigned to the Frank J. Seiler Research Laboratory in May 1970 as a research chemist.

He was born on 8 September 1941 in Springfield, Missouri, where he attended public school, graduating from Parkview High School in May 1959. He attended Washington University, St. Louis, Missouri, from 1959 until 1963 on an honor scholarship. He was granted an A.B. in chemistry in June 1963 and was commissioned in the Air Force Reserve. As a Distinguished Military Graduate of the ROTC program, he was tendered and accepted a commission in the Regular Air Force in January 1964.

His initial active duty assignment, beginning in July 1963, was at the Air Force Satellite Control Facility in Sunnyvale, California. There he served as a shift supervisor and as a computer software coordinator in the Multiple Operators Branch of System Control. He participated in the development and applications of a list-processing compiler, MOSS, which was used extensively for resource scheduling and satellite servicing conflict prediction.

In March 1967 he was reassigned to AFIT and entered the University of California at Los Angeles as a graduate student in physical chemistry. He earned the M.S. in December 1969 while continuing study on the PhD program. He is currently a doctoral candidate at UCLA. His doctoral research concerned the thermodynamics of binary solutions with emphasis on the CH_4 - CF_4 system near its critical solution temperature (90° - 100°K).

On 25 August 1962, he married Betty Sue Bucker of Springfield, Missouri. They have two daughters, Laura Lynn and Jacqueline Leigh.

Captain Raymond R. McGuire

Captain Raymond R. McGuire was assigned to the Frank J. Seiler Research Laboratory, as a research chemist in September 1969.

Captain McGuire was born 28 April 1938 in Altoona, Pennsylvania, and was graduated from the Altoona Catholic High School in 1956. He received a B.S. degree in Chemistry from the Pennsylvania State University in June 1960 and as an AFROTC graduate was commissioned into the Air Force Reserve. Captain McGuire entered Michigan State University in September 1960 under a Category C delay. During his initial stay at MSU, Captain McGuire served as a Teaching Assistant in the Chemistry Honor's program as a lecturer in inorganic chemistry. During the summer months he served as a research chemist (GS-12) at the Naval Ordnance Station, Indian Head, Maryland. Captain McGuire entered active duty in December 1965, prior to completing his degree, but returned to Michigan State University in September 1968 under the "Bootstrap" program where he completed his research and was granted a PhD in both Organic and Inorganic Chemistry in December 1969.

Captain McGuire's first duty assignment was as the Assistant Program Monitor for Chemical and Biological Weapons at Headquarters, Air Force Systems Command. In July 1967, Captain McGuire was transferred to the Biological-Chemical Division of the Air Force Armament Laboratory, Eglin AFB, where he served as a project officer until returning to school.

Captain McGuire is a member of the American Chemical Society, the Research Society of America and Sigma Xi. He has co-authored a number of papers on the photochemistry of pesticides and the kinetics of thermal decomposition of explosives.

He is married to the former Gail Sargent Crosby of Monroe, Michigan. They have two sons, Matthew and Stephen, and a daughter, Erin.

Captain David Finkleman

Captain Finkleman reported to the Frank J. Seiler Research Laboratory for his initial active duty assignment in October 1967. He is currently both a Research Associate in the Seiler Laboratory and Assistant Professor of Aeronautics.

Captain Finkleman was born in Brooklyn, New York, on 31 August 1940, and attended public schools in Washington, D. C. After graduating from the McKinley Technical High School in 1958, he entered the five-year cooperative work-study program at the Virginia Polytechnic Institute. His industrial periods were spent at the David Taylor Model Basin (currently the Naval Ship Research and Development Center), Carderock, Maryland, where he worked in the Transonic and Gasdynamics Divisions progressing from Wind Tunnel Technician to Aerospace Research Engineer. In June 1963, Captain Finkleman received a Bachelor of Science in Aerospace Engineering (cooperative option) with honors from V.P.I. At the same time he was presented one of twenty SAME medals awarded to outstanding engineering graduates in the United States. Having pursued Army ROTC and having been designated a Distinguished Military Graduate, he was commissioned in the U.S. Army.

In September 1963, Captain Finkleman transferred to the U.S. Army Reserve and was granted an educational delay to pursue graduate studies in Aeronautics and Astronautics at the Massachusetts Institute of Technology. While at M.I.T. he held jointly a General Dynamics (Fort Worth) Fellowship and a NASA Graduate Traineeship. During his final year of residence he was a Research Assistant as well. He received an S.M. in Aeronautics and Astronautics from M.I.T. in June 1964 and in September 1967, was awarded a Ph.D. His doctoral research was conducted in gasdynamics. In June 1967 Captain Finkleman requested and was granted an inter-service transfer to the Air Force, and he spent the final three months of his doctoral residence under a Category C delay.

Captain Finkleman is a member of the American Institute of Aeronautics and Astronautics, the American Association for the Advancement of Science, the Society of Sigma Xi, Phi Kappa Phi, Sigma Gamma Tau, Tau Beta Pi, the Society of American Military Engineers, and the American Society of Mechanical Engineers. He is the author of numerous papers on the analysis of viscous flows with heat and mass transfer, the dynamics of chemically reacting gases, the dynamics of radiating gases, and the optimization of tactical aircraft weapons systems.

Captain Finkleman married the former Edith Fechter on 2 February 1964. They have two sons, Theodore and Daniel.

Captain Michael D. Ciletti

Captain Michael D. Ciletti came to the Frank J. Seiler Research Laboratory in February 1968 to begin his assignment as a Research Associate in the Directorate of Aerospace-Mechanics Sciences.

Capt Ciletti was born in Washington, Pennsylvania, on 4 June 1942. He attended public and parochial schools there and graduated from Immaculate Conception High School in June 1960. In September 1960 Capt Ciletti entered the University of Notre Dame to begin studies in electrical engineering. While at the University, he participated in the Air Force ROTC program and was a Distinguished Military Graduate.

After being commissioned in the Air Force in June 1964, Capt Ciletti received a Category C educational delay from the Air Force Institute of Technology. With the aid of a National Science Foundation Graduate Traineeship he continued his studies at the University of Notre Dame and received his MSEE in 1965 and the PhD in Electrical Engineering in 1968.

Capt Ciletti's interests are in differential game theory, optimal control theory, mathematical programming, functional analysis and communication theory. He has been appointed as an Assistant Professor in the Department of Electrical Engineering. Among the courses which he has taught are courses in electronic circuits, analog computers, communication theory, control system analysis, information theory and linear system theory. While at the Seiler Laboratory, Capt Ciletti has published several papers on the theory of differential games and he co-edited the text: Differential Games: Theory and Applications, ASME, New York, 1970. He also lectured at the International Summer School on Mathematical Systems Theory and Economics at Varenna, Italy, in June 1970.

Capt Ciletti is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu and the Institute of Electrical and Electronics Engineers (IEEE). He serves as a reviewer for IEEE Transactions on Automatic Control, the Journal of Optimization Theory and Applications, and Automatica, the Journal of the International Federation of Automatic Control (IFAC). He has also been recently named as an Associate Editor of Automatica.

Capt Ciletti married Jerilynn Johnson of Washington, Pennsylvania, in August 1964. They have four daughters: Monica, Lucy, Rebecca, and Christine.

Captain Kenneth D. Senne

Captain Senne was assigned to the Directorate of Aerospace-Mechanics Sciences of the Frank J. Seiler Research Laboratory in July 1968.

Captain Senne was born in Akron, Ohio, on 14 March 1942, and moved to southern California before his first birthday. He graduated from La Habra High School in June 1960. The following September he entered Stanford University as a freshman in the class of 1964. He received his Bachelor's degree in electrical engineering with distinction, and was commissioned into the Air Force as a second Lieutenant after completing the ROTC program at Stanford.

For the next four years Captain Senne was a graduate student in electrical engineering at Stanford University. From 1964 until June 1966 he was employed half-time as a teaching assistant, during which time he helped to establish a digital circuits laboratory course. After receiving his M.S. in June 1966, he became a research assistant in the Adaptive Systems Laboratory and received his Ph.D. in June 1968.

During the summer of 1965 Captain Senne was employed as a systems engineer by the Instructional Systems Development Division of IBM, where he worked on the logic design for a computer-assisted instruction (CAI) system.

Captain Senne's dissertation research was concerned with the theory of adaptive linear estimation and its implementation by digital computers. His technical interests include mathematical systems theory, particularly stochastic optimization techniques and applications of functional analysis to detection, estimation, and control. He is a member of Tau Beta Pi and IEEE.

Captain Senne participated in the Stanford overseas study program as an undergraduate, spending six months at Stanford in Germany near Stuttgart in 1961. Also during his undergraduate years he played clarinet in the Stanford marching band and concert band.

Captain Senne was married to the former Linda Prusiecki of Hobart, Indiana, on 19 June 1964, whom he met as a Stanford student. They have no children.

Captain Robert E. Cochoy

Captain Robert E. Cochoy was assigned to the Directorate of Chemical Sciences as a research chemist for his initial active duty assignment in February 1969.

Captain Cochoy was born in Akron, Ohio, on 30 July 1942. He attended public schools in Akron where he graduated Valedictorian from Kenmore High School in 1960. In the fall of 1960, Captain Cochoy entered the University of Akron, Akron, Ohio. In June 1964, he received a B.S. in chemistry, cum laude, and was commissioned a second lieutenant, USAF Reserve.

In the fall of 1964 he entered the Yale University Graduate School as a Category C USAF Reserve Officer. He was the recipient of NIH Fellowships for four years. Three of these years he was a teaching fellow in Organic Chemistry. He was awarded an M.S. degree in chemistry in 1966, and an M.Phil. degree in 1968. He fulfilled the requirements for his PhD in Organic Chemistry in February 1969 and was awarded the degree in June 1969. Captain Cochoy's research concerned the synthesis and electrophilic reactions of cyclopropanols.

Captain Cochoy married the former Jean Bowen on 7 July 1966. They have a son, John.

Captain Cochoy is a member of the American Chemical Society, Phi Sigma Alpha, and Phi Eta Sigma.

Captain Donald D. Potter

Captain Donald D. Potter was assigned to the Directorate of Chemical Sciences as a research chemist in February 1971.

Capt Potter was born on 5 November 1943 in Chadron, Nebraska. He attended public schools in Valentine and Grand Island, Nebraska. Upon graduation from Grand Island Senior High School in 1962, he received a four year National Merit Scholarship, sponsored by the Sears Merit Foundation.

In the fall of 1962, he entered Grinnell College, Grinnell, Iowa. In May 1966, he received a BA with a major in Chemistry, and was commissioned, through AFROTC, a Second Lieutenant, USAF Reserve. In June 1966, he entered the University of Nebraska Graduate School as a Category C USAF Reserve Officer. He pursued graduate study in organic chemistry under the direction of Professor H. E. Baumgarten.

Capt Potter was called to active duty in August 1968. His initial active duty assignment was as a project engineer at the Air Force Armament Laboratory, Eglin AFB, Florida, from August 1968 through January 1971.

Capt Potter is a member of the American Chemical Society.

Capt Potter married the former Judy Quandt of Hammond, Indiana, in July 1969.

Captain John G. Breland, Jr.

Capt John G. Breland will be assigned to the Directorate of Chemical Sciences in September 1971.

Capt Breland was born on 22 June 1941 in Charleston, South Carolina, and graduated from the Holly Hill, South Carolina, High School in 1959. He attended the University of South Carolina and received a BS in Chemistry degree in 1963. Upon graduation, he was commissioned in the Air Force Reserve as a Distinguished Military Graduate of AFROTC.

Under a Category C educational delay he continued his studies at South Carolina and received his PhD in Organic Chemistry in 1967. His research involved the synthesis and characterization of polynuclear ferrocene compounds. He was the recipient of National Science Foundation and Woodrow Wilson Fellowships and served as both teaching and research fellows.

He entered active duty as a First Lieutenant in 1967 and was assigned to the Air Force Materials Laboratory at Wright-Patterson AFB, Ohio. As a member of the Elastomers and Coatings Branch, he was instrumental in the development of speciality coatings for aircraft transparencies and the protection of advanced composite materials from natural lightning discharges.

During the spring of 1969, Captain Breland represented AFML in the Air Force Systems Command Liaison Office in Southeast Asia. In June 1970, he became a member of the Laboratory Director's staff as Deputy Assistant for Systems Support.

Capt Breland is a member of the American Chemical Society, Phi Beta Kappa, Sigma Xi, and the Society of Aerospace Material and Process Engineers. While at AFML, he co-authored and presented several papers on speciality coatings and electrical phenomena.

1Lt Robert A. Golobic

1Lt Robert A. Golobic reported to the Frank J. Seiler Research Laboratory in March 1971 as a research associate in the Directorate of Aerospace-Mechanics Sciences. In addition to his research duties, Lt Golobic teaches in the Department of Aeronautics.

Lt Golobic was born on 2 April 1943 in Cleveland, Ohio. He was graduated from St. Joseph High School in Cleveland, Ohio, in 1961 and entered Ohio State University that autumn. He was graduated from Ohio State University with a Bachelor of Aeronautical and Astronautical Engineering in June 1966 and was awarded a reserve commission in the Air Force through the ROTC program. He was also designated a Distinguished Military Graduate.

During his undergraduate career, Lt Golobic became a member of Sigma Gamma Tau, a national aeronautical engineering honorary society, as well as a member of the Sphinx, a university honorary society.

Lt Golobic continued his graduate studies at the Ohio State University and was granted an MSc in Aeronautical and Astronautical Engineering in August 1967. He completed a thesis entitled, "End-wall Radiative Heat Transfer Behind a Reflected Shock Wave in Air in a Shock Tube". It was subsequently published in the September 1968 issue of the AIAA Journal. He continued at Ohio State University and was granted a PhD degree in June 1971. His dissertation was entitled, "A Laboratory Study of Strong Shock Waves in Xenon". During his graduate career he joined the AIAA and AIP and became a member of the Society of Sigma Xi.

Lt Golobic is active in the National Association of Rocketry and is Educational Director of that organization. He is also the Advisor for the USAF Academy Model Rocket Section.

Lt Golobic married Rose Ann Grady on September 13, 1969.

Dr. Hans Reich

Dr. Reich was born in Graudenz (formerly Germany) on 22 November 1908. He studied chemistry at the Polytechnic Institutes of Hanover and Dresden (Germany) and received his PhD from the University of Munich in 1934.

After two positions in Germany (1935-1937), he worked from 1938 until 1947 as a research chemist at the Pharmaceutical Institute of the University of Basel, Switzerland.

In 1947, he emigrated to the United States and became associate research professor at the University of Utah Medical School in Salt Lake City. Six years later, he accepted a position at the Biochemistry Department, University of Wisconsin, Madison, and in 1960 he moved to Colorado Springs to become assistant director at the Lasdon Foundation Research Institute of Chemotherapy.

Dr. Reich joined the Directorate of Chemical Sciences of the Frank J. Seiler Research Laboratory in September 1964. He is a member of the American Chemical Society, Sigma Xi, and the American Society of Biological Chemists.

On 9 June 1946, he married Elsa Tannenblatt of Berne, Switzerland. Dr. and Mrs. Reich reside in Colorado Springs.

Mr. J. Lloyd Pflug

Mr. Pflug was born in Joplin, Missouri, on 21 March 1925. He moved to Colorado Springs in 1931, where he attended public school, graduating from Palmer High School in June 1943. After a tour of duty in the Army, he entered Colorado College and received his Bachelor of Science degree in June 1950.

For the next year, Mr. Pflug was a graduate student in the Chemistry Department at the University of California at Los Angeles. He transferred in the fall of 1951 to the University of Denver and received his Masters Degree in the summer of 1952.

Mr. Pflug joined the Research and Development Group at the Dow Chemical Company, Rocky Flats Division, Golden, Colorado, in September 1952. He remained in that position until June 1962, at which time he joined Aerojet Nucleonics, San Ramon, California, as an Analytical Chemist.

In November 1964, Mr. Pflug was assigned to the Directorate of Chemical Sciences of the Frank J. Seiler Research Laboratory. He is a member of the American Chemical Society and the Phi Beta Kappa fraternity.

On 30 June 1950 he married Turza Gene Briscoe of Colorado Springs, Colorado. They have three children, Patricia Anne, John David and George Ronald.

EQUIPMENT LIST

LIST OF MAJOR EQUIPMENT

Major Equipment Owned by the Frank J. Seiler Research Laboratory

Nuclear Magnetic Resonance Spectrometer	
Model A-60-Varian Associates.	\$ 24,950
X-Ray Equipment, Norelco	46,000
X-Ray Diffraction Cameras and Associated Equipment	3,881
Carbon-Hydrogen-Nitrogen Analyzer- F&M Scientific, Model 185	4,090
Automatic Gas Chromatograph - F&M Scientific, Model 770.	7,593
Model DU Spectrophotometer - Beckman Instruments, Inc.	236
Beckman Model IR4 Infrared Spectrophotometer	15,000
Spinning Band Columns.	1,282
Abbe Refractometer	745
International Automatic Centrifuge	759
Zone Refiner Apparatus - Fisher Scientific	685
Beckman Zeromatic pH Meter	340
Tube and Muffle Furnaces and Controllers	3,096
Isolator Lab (Dry Box) - Fisher.	1,170
Differential Thermal Analysis Apparatus.	700
Precision Fractionation Apparatus - Todd Scientific.	1,038
X-Y Recorder - Mosely.	1,950
Precision K-3 Potentiometer, Leads & Northrup.	125
Low Density Shock Tube and Instrumentation	30,141
Water Baths.	2,178
Cathometer	250
Beckman Research pH Meter.	795
Beckman GC-4 Gas Chromatograph	7,169
Photolysis Reaction Chamber.	300
High Vacuum Systems.	700
Cryogenic Liquid Facilities.	395
Spectra-Physics CW Laser Model 130.	3,004
Harrison Labs Power Supply 6522A	255
Mass Spectrometer, Dupont, Model 21-491.	37,750
Camera Sets and Scopes	15,658
Balances	2,719
Beckman Electroscan 30	4,202
Lathe Engine Floor Model	3,470
Laboratory Assemblies.	15,200
Height Unit (Lab Assembly)	8,759
Pumping System NCR	3,300
Laser Continuous Wave.	3,004
Precision Servo Test Fixture and Kit	97,000
Microflat Granite.	950
Multimeter 5 Digit	1,775
Plotter System 7004B	4,515
Digital Control (SEL).	34,750
Capacity Expansion Kit SEL 810B Digital Control Unit	47,260
HP12597A-003 Duplex Register	800
Plotting Output Writer Wang.	3,377

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Major Air Force Academy Items Being Used by FJSRL

GC 2-A Gas Chromatograph (Beckman, modified by FJSRL)
DK-2A Spectrophotometer (Beckman, UV-Vis, modified by FJSRL)
Perkin-Elmer IR-137 Infrared Spectrophotometer
Pace Analog Computer
Jarrell-Ash 1.4 Meter Emission Spectrograph
Burroughs B5500 Digital Computer with 20 Remote Terminals
Cal Comp 570/565 Plotter
Precision Servo Test Table

EQUIPMENT ITEMS PROCURED FOR USAF ACADEMY PROJECTS

During FY70 FJSRL purchased and presented to the USAF Academy \$64,616 worth of equipment items to be used in sponsored research. This was distributed among the following Faculty Departments:

Aeronautics	\$ 7,392
Engineering Mechanics	9,905
Civil Engineering	729
Life Sciences	46,490

The following table lists the individual equipment items purchased during FY71:

1 ea	Spectral Calibration	\$ 402.15	Aeronautics
1 ea	Dredge	130.72	Civil Engineering
1 ea	Photographic Systems (Rental)	12000.00	Civil Engineering
1 ea	Profilometer	1395.00	Aeronautics
1 ea	Power Supply	766.50	Physics
1 ea	Blast Cleaning Cabinet	478.80	Aeronautics
1 ea	CO ₂ Laser Spectrum Analyzer	924.00	Physics
1 ea	Infrared Detector	1200.00	Physics
1 ea	Roots Pumping System	2578.00	Physics
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		\$ 19875.17	