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AFIT School of Engineering Contributions to Air Force Research and Technology. Calendar Year 1971

School of Engineering, Air Force Institute of Technology

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AFIT SCHOOL OF ENGINEERING
CONTRIBUTIONS TO AIR FORCE
RESEARCH AND TECHNOLOGY

Technical Report AFIT TR 72-1

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AFIT SCHOOL OF ENGINEERING CONTRIBUTIONS TO AIR FORCE RESEARCH AND TECHNOLOGY

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AFIT School of Engineering

Contributions to

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ABSTRACT

This report contains abstracts of Master of Science theses and Doctoral Dissertations completed during the 1971 calendar year at the School of Engineering, Air Force Institute of Technology.

PART I

INTRODUCTION

Parts II and III of this report contain abstracts of Master of Science theses and Doctoral Dissertations completed by students at the School of Engineering, Air Force Institute of Technology during the 1971 calendar year.

Most abstracts list the AD number which may be used to order that particular thesis or dissertation from the Defense Documentation Center (DDC) or from the Federal Clearing House. Those without AD numbers may be obtained on interlibrary loans from the Air Force Institute of Technology Library (AFIT/LD).

Part IV of this report contains a list of sponsoring organizations together with the abstract numbers of the theses so sponsored. Part V is a subject index.

In addition to the research and development effort represented by these publications, the School of Engineering published two books, eight technical reports, and 87 journal articles during the 1971 calendar year.

PART II

ABSTRACTS OF MASTER OF SCIENCE THESES

1 AERODYNAMIC INTERFERENCE BETWEEN A WING AND A SLENDER CYLINDRICAL STORE

Paul M. Sullivan, Maj, USAF 76p GA/MC/71-6
Advisor: Major F. E. Eastep Lab Sponsor: AFFDL

Aerodynamic interference between an aircraft and a store carried beneath its wing is investigated using the simplified physical model of a uniform wing of infinite span and a slender body of revolution positioned beneath the wing. The wing is represented by a vortex filament, the store by a distribution of sources and doublets along its axis of revolution, and potential flow is presumed to exist. The aerodynamic forces acting on the store while it is attached to the aircraft are computed using this model. They vary inversely with the distance between the geometric center of the store and the wing vortex. The aerodynamic moment acting on the captive store varies directly with the angle of attack, and is only slightly dependent on the store position. The trajectory that the store follows after it is released depends on its mass, initial position relative to the wing, and initial angle of attack. If a store is symmetric and homogeneous, it is unstable after release, and rapidly violates the small angle assumptions of this study. Several trajectories are computed, and show that the aerodynamic loads can be large enough to propel a store of considerable mass into the aircraft that released it.

2 ANALYTICAL STUDY OF BOUNDARY–LAYER GROWTH IN A DIVERGING CHANNEL

Walker E. Berkshire, Jr., 1st Lt, USAF 54p GA/AE/71-2
Advisor: Major J. V. Kitowski Lab Sponsor: ARL

An analytical study of two-dimensional viscous compressible flow in diverging channels was made for a parabolic wall channel and a straight wall channel with varying initial centerline Mach numbers, degrees of wall divergence, and initial centerline-to-wall enthalpy ratios. The system of governing equations had been reduced to a mathematically parabolic system of nonlinear partial differential equations by means of slender channel approximations and an order of magnitude analysis. The governing equations were then solved using an implicit finite difference technique which reduced the problem to that of a set of simultaneous linear algebraic equations which were well suited for solution on a digital computer. Special case studies for air showed that the only profiles significantly affected by the parabolic wall channel were those of transverse velocity, pressure, and centerline Mach number. The degree of wall divergence, the initial centerline Mach number, and the initial centerline-to-wall enthalpy ratio greatly influenced the retarding viscous forces near the channel wall and hence had a significant effect on all the profiles, especially those of displacement thickness, pressure, skin friction, and Nusselt number. Increasing wall divergence and wall cooling were seen to reduce the retarding viscous forces whereas increasing initial centerline Mach number increased the retarding viscous forces.

3 AN APPARATUS FOR MEASURING SMALL VARIATIONS IN THRUST

Monte T. Lorrigan, Capt, USAF 49p GA/ME/71-1
Advisor: Dr. A. J. Shine Lab Sponsor: AFPL

This study is a development of instrumentation and techniques for evaluating performance of small convergent-divergent nozzles with a precision of at least 0.99. The nozzles tested were mounted on a pendulum thrust chamber. During testing the thrust chamber would deflect an aluminum strip on which was mounted a strain gage used to evaluate thrust for various chamber pressures. A throat area of approximately 1/2 sq in was used. Thrust values of 29–30.5 $1b_f$ were obtained at a chamber pressure of 110 in Hg gage. Two of the nozzles were submerged 0%, 20%, and 40% of overall nozzle length.

4 A FUNCTION MINIMIZATION TECHNIQUE APPLIED TO A HUMAN OPERATOR MODELING PROBLEM

Darryl D. Dixon, Capt, USAF 57p GA/EE/71-1
Advisor: Capt C. N. Day Lab Sponsor: AMRL

A modeling technique is developed which can be used to obtain a linear mathematical description of an unknown system. The modeling technique uses a method of functional minimization to adjust the parameters of a single input, linear, time invariant set of state equations (the model) to obtain the best match, in the least mean-squared-error sense, between the model and the system outputs. The functional minimization method requires the derivatives of the states of the model with respect to the model parameters. These derivatives are found by the use of sensitivity analysis. The modeling technique is tested by applying it to model a known system. The technique is also applied to model a human operator in a single axis compensatory tracking task.

5 METHODS AND DESIGN OF SIMPLE DEVICES FOR ON–BOARD AND GROUND–BOUND ORBIT DETERMINATION

Daniel H. Jean, Maj, USAF | 88p | GA/MC/71-1
Advisor: Prof P. Bielkowicz | Lab Sponsor: AFAL

Simple non-electrical methods and devices for orbit determination on the basis of explicit navigation are examined. Principal measuring devices discussed are the sextant, stadimetric instruments, and almucantars. Computational methods for solving the geometric orbital parameters are focused on adaptations of the velocity hodograph. Discussion includes sample problems and a general analysis of inherent errors.

6 NATURAL FREQUENCIES OF MEMBRANES AND PLATES WITH SLIGHTLY NONCIRCULAR BOUNDARIES

Darrel L. Nesseth, Capt, USAF | 114p | GA/MC/71-7
Advisor: Major F. E. Eastep | Lab Sponsor: AFFDL | AD 729778

A theoretical study was made to determine the first natural frequencies of noncircular membranes and plates using regular perturbation theory. A characteristic equation for frequency is obtained by assuming the mode shape for the noncircular plate can be represented by an asymptotic series which includes the mode shape expression for a circular membrane or plate. The boundary conditions are applied to the assumed mode shape and through Taylor series expansions about a chosen circular boundary, a characteristic equation for any noncircular membrane or plate is obtained. For elliptical membranes and plates, the values of natural frequency obtained by this method compare with values determined by other methods for ellipse eccentricities up to 0.6. The natural frequencies of square membranes and plates are predicted with accuracies of 3.9% and 7.5%, respectively. The results indicate that this method may be applied to any noncircular membrane or plate with various combinations of boundary conditions in order to obtain an approximate frequency estimate.

7 NAVIGATIONAL TECHNIQUES FOR INTERSTELLAR RELATIVISTIC FLIGHT

David K. McMaster, Capt, USAF | 67p | GA/MC/71-2
Advisor: Major G. M. Anderson | Lab Sponsor: AFIT

In this study closed form expressions are developed for the inertial position and velocity of a spacecraft traveling at relativistic velocities in terms of parameters which can be measured by an observer located on the spacecraft. It is assumed that (1) the guidance system maintains a one-dimensional direction of travel toward the destination star, (2) there are no gravitational or drag forces acting on the spacecraft, and (3) the stars used for measurement are located in the XY plane. Using the Theory of Relativity transformation equations between an event in the sun centered XYZ coordinate system and the same event in the spacecraft centered xyz coordinate system are used to develop a wavelength shift equation, which relates the inertial wavelength λ of light emitted from a star to the apparent wavelength λ' measured by an observer on the spacecraft, and a relativistic aberration equation which relates the inertial angle θ of the position of a star to the apparent position angle θ' measured by an observer on the spacecraft. The wavelength shift equation is used to develop the velocity measuring method and the relativistic aberration equation is used to develop the position measuring method. The methods are shown to be identical for spacecraft traveling at either constant velocity or constant acceleration. An error analysis shows that the error in velocity determination is minimized by measuring the wavelength and position angle of light emitted by the sun and the error in position determination is minimized by measuring the position angle of stars for which the light emitted does not appear to shift in wavelength.

8 OPTIMAL INTERSTELLAR TRAJECTORIES WITH RELATIVISTIC ROCKETS USING COMBINED THRUST AND ACCELERATION LIMITED CONTROL

James R. Anderson, Maj, USAF | 106p | GA/MC/71-3
Advisor: Major G. M. Anderson | Lab Sponsor: AFIT

The purpose of this study is to investigate the characteristics of one-dimensional relativistic minimum time trajectories of single-stage rockets subject to both a thrust constraint and an acceleration constraint. Gravitational and drag forces are neglected. The rocket exhaust velocity is considered constant, and the maximum acceleration, as measured on the rocket, is about 1 g. The rocket starts from the origin of an inertial system at zero time and velocity. The two-point boundary-value problem that satisfies the necessary conditions is set up using Pontryagin's minimum principle. It is solved to provide the relativistic optimal control law for the minimum time trajectories. Assuming zero final velocity, the characteristics of the relativistic minimum time trajectories are determined. The results are compared with those for rockets subject to a thrust constraint only and rockets subject to an acceleration constraint only. Two optimal control sequences, to a positive final position and zero final velocity, are obtained for the rocket subject to both thrust and acceleration constraints. The minimum time trajectories provided by these two control sequences are both improvements

over those for the strictly thrust constrained rocket, but neither produces time less than can be obtained with the strictly acceleration constrained rocket. The two optimal control sequences found in this study make possible continuous improvement in the minimum time trajectories as technology advances from the strictly thrust constrained rocket to the strictly acceleration constrained rocket.

9 A PRELIMINARY DESIGN OF A REMOTELY–CONTROLLED GLIDER FOR A LONG–LINE OPERATION

Elbridge L. Snapp III, 1st Lt, USAF 101p GA/AE/71-1
Advisor: Prof H. C. Larsen Lab Sponsor: AMRL

Low-level, covert observation of a small area of ground may be obtained by an unmanned glider towed from a large aircraft and suspended in Long-Line-Loiter. This glider is equipped with a Visually-Coupled Control System operated through a Low-Light-Level Television camera. The glider has a gross weight of 442.5 lb of which 282.3 lb is payload. The vehicle features a high wing and a constant-chord airfoil with 30 ft span. Overall vehicle length is 17.7 ft. Wings-level stall speed is 35.8 knots. The glider exhibits static longitudinal, lateral, and directional stability. Attaching the tow cable to the top of the fuselage above the vehicle center of gravity allows the glider to be flown in high-speed trail or suspended in Long-Line-Loiter.

10 TOWARD A DIFFERENTIAL GAME SOLUTION TO A PRACTICAL TWO AIRCRAFT PURSUIT–EVASION PROBLEM IN THREE–DIMENSIONAL SPACE

S. Miles D. Williamson-Noble, FltLt, RAF 113p GA/MC/71-5
Advisor: Major G. M. Anderson Lab Sponsor: AFFDL AD 729777

A practical two aircraft pursuit-evasion problem in three-dimensional space is posed as a zero sum, perfect information differential game. The purpose of this thesis is to solve this differential game and to obtain optimal or near optimal closed-loop control laws for the two players. Three models of the aircraft dynamics are used. The first model is primarily a realistic one, and as the state equations are non-linear and highly coupled, it is not possible to obtain optimal closed-loop solutions. The second model is a simplified version of the first. Using this model, the solution is carried further--the costate variables are eliminated from the controls--but closed-loop solutions still cannot be found. The third model used has different controls from the other two, but is roughly similar in nature Optimal closed-loop controls are obtained for this model. The results obtained from these models show that the three-dimensional problem cannot be considered as a simple extension of the two-dimensional game. The necessary inclusion of the bank angle or a similar control introduces an extra order of complexity into the problem. As exact optimal closed-loop control laws for the realistic model are not available, the results of the analysis are presented in two ways. Firstly, open-loop minimax solutions for all three models are generated numerically by backward integration from a selection of terminal states. Two-dimensional views of these three-dimensional trajectories are given in both real and relative space. Secondly, pseudo optimal controls for the realistic model are derived, based on the closed-loop controls obtained for the simplest of the three models. These pseudo controls are then used with the standard dynamics to integrate forward in time from the states reached by backward integration of the realistic open-loop solutions. The pseudo closed-loop solutions give a good approximation to the open-loop solutions for the realistic model under almost all the conditions tested.

11 WIND TUNNEL MEASUREMENT OF AIRBORNE TOWED CABLE DRAG COEFFICIENTS

Burdette J. Barnes, Jr., Capt, USAF and John L. Pothier, Capt, USAF 59p GA/MC/71-4
Advisor: Prof H. C. Larsen Lab Sponsor: AMRL

Four tow cables used in the AMRL Long Line Loiter program were tested to determine their drag characteristics. Each cable was tested in angle of attack range $\alpha = 15^{o} - 90^{o}$ and Reynolds number range RN= 12,000–54,000. Tests were performed in the AFIT five-foot subsonic wind tunnel. The cables were of two types: (1) Two circular, hollow-woven polypropylene lines, for which C_d vs Rn was generally concave up for high α and nearly linear for the low α. Maximum C_d at $\alpha = 90^{o}$ was near 1.2; the critical Rn was approximately 35,000. (2) Two flat (t/c = 1/2) hollow-woven nylon lines for which C_d vs Rn was concave down for high α and nearly linear for low α. Maximum C_d at $\alpha = 90^{o}$ was near 1.0; no critical Reynolds number was reached during flat cable testing.

12 THE ANALYSIS AND CLASSIFICATION OF RANDOM APERIODIC SIGNALS

Charles F. Hall, 1st Lt, USAF 114p GE/EE/71-11
Advisor: Dr. M. Kabrisky Lab Sponsor: AMRL AD 722647

Two classes of random aperiodic signals were analyzed using one- and two-dimensional Fourier transforms, Low-frequency filtering in the transform domain and the Euclidean distance metric were used to classify signals in one of the two classes. Linear decision boundaries, clustering algorithms, and a training algorithm

using a linear categorizer were also used during the analysis. It was found that low-frequency spatial filtering in the two-dimensional Fourier-transform domain gave complete separation of the two classes of signals analyzed.

13 APPLICATION OF AN IMAGE CLASSIFICATION MODEL TO THE RECONNAISSANCE PROBLEM

Robert S. Roberson, 1st Lt, USAF | 47p | GE/EE/71-23
Advisor: Dr. M. Kabrisky | Lab Sponsor: AMRL | AD 886111

The purpose of this investigation is to determine the applicability of a proposed model for visual image classification to the problem of detection and classification of "interesting" images in aerial reconnaissance data. The model is described and its mathematical properties discussed. The strengths and weaknesses of the model are revealed. Recommendations are made which should improve the model's performance with respect to the reconnaissance problem.

14 APPLICATION OF PATTERN RECOGNITION TECHNIQUES TO THE ANALYSIS OF GAMMA-RAY SPECTRA

Terry R. Murrow, 1st Lt, USAF | 36p | GE/EE/71-20
Advisor: Dr. M. Kabrisky | Lab Sponsor: ARL | AD 723278

The purpose of this investigation is to test a pattern recognition system's ability to detect Gaussian peaks in gamma-ray spectra. The pattern recognition system, based upon a proposed model of the human recognition system, uses Fourier transforms as a vital part of the recognition process. A brief description of the biological bases for the model and the necessary mathematical background are presented. A system which was successful in detecting those peaks it had been "taught" is described.

15 AUTOMATIC CLASSIFICATION OF TITANIUM ALLOY MICROSTRUCTURES BY USING FILTERED FOURIER PATTERN RECOGNITION TECHNIQUES

Joseph A. Jones, Capt, USAF | 101p | GE/EE/71-14
Advisor: Dr. M. Kabrisky | Lab Sponsor: AMRL | AD 886110

A method for automatic classification of titanium alloy microstructures is presented. The properties of Fourier transforms are reviewed, and then spatial filtering, the prime ingredient of pattern recognition, is discussed. Data preparation and recording techniques are analyzed, and the classification algorithm is outlined. Finally, the results obtained from the recognition process are presented. The conclusion is reached that this process can be used to recognize the microstructure of Ti-6A1-6V-2Sn, but more research is required in the area of data preparation and recording in order to increase the accuracy of the process.

16 AUTOMATIC REDUCTION OF FLOW TABLES

James P. Rutledge, Capt, USAF | 158p | GE/EE/71-1
Advisor: LtCol F. M. Brown | Lab Sponsor: AFIT | AD 880858

The purpose of this thesis is to compare two methods of minimizing incompletely specified sequential machines by computer. One method used was a tree-search procedure based upon Mage's ideas. The other method used was a variation of Darr's algorithm. FORTRAN program listings and directions for use are included in the thesis. The program accepts input data in the form of a flow table and presents its results in the same form. Intermediate outputs are available, if desired, giving the implicant table, prime compatibles with their class sets, and the CC table.

17 AUTOMATIC REDUCTION OF STATE TABLES USING KELLA'S METHOD

Ogal B. Claspell, Capt, USAF | 106p | GE/EE/71-5
Advisor: LtCol F. M. Brown | Lab Sponsor: AFIT | AD 883201

Traditional methods for reducing the number of states of incompletely specified sequential machines require increasing the number of states before reduction to a minimal reduced machine (MRM). Kella's method starts with one state and adds states one at a time until an MRM is realized. There are three parts to Kella's method. The first adds an incompatibility column to the state table. The second adds state k to a system of subsets and generates an irreducible machine. The third part iterates part two until a solution is produced; it then insures that the solution is the MRM. A computer program is listed in the report which accepts a state table and reduces it using Kella's method.

18 AN AUTOMATIC SPEECH RECOGNITION SYSTEM BASED ON A PHYSIOLOGICAL MODEL

Tony R. Gilligan, 1st Lt, USAF — 90p — GE/EE/71-10
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 883203

Physiological experiments are cited which indicate that auditory information is presented to the cerebral cortex in a representation similar to that of the other sensory systems. A cortical interconnection model, based on a spatially filtered, two dimensional Fourier transform process is taken from a model of the human visual system and adapted to model the auditory cortical interconnection scheme. An Analog Ear, which models the mechanical sections of the human ear, is combined with the interconnection model to form an elementary model of the pattern recognition aspect of the human auditory system. An on-line realization of the model is constructed and investigated. Near real-time recognition rates averaging 84% were attained with a fifty word vocabulary, and rates averaging 92% were attained with a forty word subset of the larger vocabulary. Three male speakers were used, with system self-adjustment to the speaker being accomplished.

19 CHROMATIC PATTERN RECOGNITION

Charles W. Blackford, Jr., Capt, USAF — 50p — GE/EE/71-4
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 722853

An achromatic pattern recognition model is modified to process chromatic objects. The theory of color television is used to obtain pattern information in terms of one luminosity and two opponent chromaticity functions. Two-dimensional Fourier transformations of the two color functions are performed. Color identification is then made by correlation with transform prototypes of colored chips previously derived and stored. The object is identified in a similar manner by transforming its luminosity function. A digital simulation of the model is conducted using the English alphabet and 84 colors representative of the color spectrum. All letters and their colors are successfully identified, including conditions where pattern brightness varies. Characters were also identified when the chromaticity varied. It is concluded that the modified model can be trained to identify any object's color.

20 THE CLASSIFICATION OF CHINESE CHARACTERS BY SPATIAL FILTERING TECHNIQUES

Lawrence A. Ankeney, Capt, USAF — 44p — GE/EE/71-2
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 722852

A method is proposed in which nondefined Chinese characters may be uniquely classified, thus making them compatible for machine translations. An optical-digital device is used to locate nondefined geometric shapes within Chinese characters via spatial filtering techniques and cyclic cross-correlation. Seventeen nondefined geometric shapes are found in a 98 character sample which is representative of a ten thousand Chinese character vocabulary. Preliminary results indicate that 60 percent of the geometric shapes are identified exactly and over 90 percent can be identified within specific tolerances. Geometric shape energy content is shown to be pertinent in the decision process.

21 COMPUTER REDUCTION OF SUBSET–SPECIFIED SEQUENTIAL MACHINES

William K. May, LT, USCG — 175p — GE/EE/71-19
Advisor: LtCol F. M. Brown — Lab Sponsor: AMRL — AD 883439

Recently Purnhagen has developed a new and generalized theory of state-reduction of sequential machines. The new theory allows for the possibility of conditional choices in any cell of the flow table representing a sequential machine. Such a sequential machine is called subset-specified. Purnhagen's work, which closely parallels that of Paull and Unger, gives a state-reduction procedure to formulate a conventional CC table for a subset-specified sequential machine. Using the Purnhagen theory, a FORTRAN IV computer program was developed which formulates a CC table for a subset-specified sequential machine. The largest machine capable of being solved by this program is one of 35 states, 10 inputs, 2 outputs, and 8 conditional choices for any next-state/input combination. Computer solutions of example problems agreed with hand-calculated solutions. Actual computer time required for the solution of each of five six-state example problems ranged from 2 to 423 seconds. Since both completely-specified and incompletely-specified sequential machines are special cases of subset-specified sequential machines, this program has wide spread application in the automatic state-minimization of any type of sequential machine.

22 CONDUCTION MECHANISMS IN EPITAXIAL GALLIUM ARSENIDE

Robert J. Kunkle, 1st Lt, USAF — 68p — GE/EE/71-17
Advisor: Capt T. G. Owen — Lab Sponsor: AFAL — AD 722650

Electrical conduction in high quality epitaxial GaAs is quantitatively explained for low fields and temperatures from 4°K to room temperature. Other conduction mechanisms found in less pure GaAs are also discussed. A technique for making Hall bridges in epitaxial material is described, as well as the technique and

equipment for Hall effect measurements. A computer routine is presented which solves for impurity concentrations from Hall mobility and resistivity in the temperature range 15°K to 30°K together with room temperature Hall coefficient.

23 DESIGN AND ANALYSIS OF A SWITCHOVER–REDUNDANT SYSTEM

Wadie Smallen, Capt, USAF — 110p — GE/EE/71-27
Advisor: Prof T. L. Regulinski — Lab Sponsor: AFCRL — AD 883207

A design is presented for a solid state, switchover-redundant system with four–1200 ohm resistive loads. The system switches to the next load in sequence if the resistance of the on-line load changes by more than ±12.5%. The design feasibility was demonstrated by actual construction of the system using logic simulator components. The mathematical model given for the system is valid in the continuous time domain for use with any failure density function for the components used. A parameter variation analysis using Schmoo plots shows the acceptable component variations that are permitted.

24 A DIGITAL SYSTEMS LABORATORY

Dion J. Dostaler, Capt, USAF — 78p — GE/EE/71-8
Advisor: LtCol F. M. Brown — Lab Sponsor: AFIT

The Electrical Engineering Department of AFIT has for some years provided courses in the theoretical concepts of discrete-state systems. A need now exists in the department to include practical applications of these studies. This is best done through the use of a digital systems laboratory. The laboratory described in this thesis incorporates a core memory system, an ASR 33 teletype input-output device and sufficient logic to construct a small computer. The logic is state-of-the-art TTL integrated circuit modules. A patchcord system is used for interconnecting the logic. The result is a useful, flexible facility.

25 A HYBRID COMPUTER STUDY OF HUMAN MODEL MATCHING USING REGRESSION ANALYSIS

Donald A. Schlough, 1st Lt, USAF — 65p — GE/EE/71-25
Advisor: Dr. F. M. Holden — Lab Sponsor: AMRL — AD 883206

The purpose of this study is to develop a hybrid computer implementation of a parameter identification technique using statistical regression analysis. The technique is developed for the identification of parameters in an assumed model for the human controller while he is performing a single axis compensatory tracking task. The performance of the technique is considered in various situations so as to observe the accuracy of the identification and to what situations the modeling technique may be applied. It is found that the technique is applicable in most situations where the frequency content of the input forcing function is less than ten radians per second.

26 HYBRID MODE PROPAGATION ALONG AN ARRAY OF DIELECTRIC WAVEGUIDES

George D. Peterson, Capt, USAF — 56p — GE/EE/71-22
Advisor: Dr. C. M. Zieman — Lab Sponsor: AFAL — AD 883205

This study provides an approximate theory of surface guided waves along a hexagonal array of lossless dielectric fibers. The boundary-value problem is formulated in a manner similar to the Wigner-Seitz approximate model of wave propagation in an atomic polyhedron. A formal solution is presented and numerically solved for fibers with the approximate optical properties of the human foveal cones. Mode designation is discussed and applied to the solution of the eight lower order hybrid modes. The results show that hexagonal arrays of dielectric fibers with the optical characteristics of human foveal cones are not significantly coupled over the visual range.

27 AN INSTRUCTIONAL DIGITAL CALCULATOR

Robert D. Doyle, Capt, USAF — 84p — GE/EE/71-9
Advisor: LtCol F. M. Brown — Lab Sponsor: AFIT

This is a description of a digital calculator built at AFIT to be used as an instructional aid. The calculator has four, 12–bit operation registers and a 12–bit instruction register and is constructed of diode-to-transistor and transistor-to-transistor integrated circuits. It will perform a minimum of fifteen different operations that might be found in an arithmetic unit of a computer. The calculator can be operated manually or in either one of two automatic modes. Addition and subtraction is accomplished by using a serial full adder. The multiplication and division processes require positive, signed fractional binary numbers. The division process uses the restoring method.

28 AN INVESTIGATION OF GLIDE–SLOPE INFORMATION RATE REQUIREMENTS FOR A LOW–VISIBILITY AIRCRAFT LANDING

Meyer D. Zuckerman, 1st Lt, USAF | 82p | GE/EE/71-30
Advisor: LtCol R. A. Hannen | Lab Sponsor: AFFDL | AD 722655

The glide-slope information rate requirement for a low-visibility landing approach is studied. The analysis uses a Kalman filter-optimal control combination to simulate the control system of a DC-8. Both noisy and noise-free measurements are considered. The results consist of a measure of the probability of missing an approach, as a function of the sample rate of the scanning beam landing guidance. Results indicate a "knee" at 6 samples per second, with rapid changes in performance in the region from 2–6 samples per second. The position of the knee appears to be insensitive to changes in either deterministic winds or airspeed constraints.

29 MODELING MAINTAINABILITY FOR AIRCRAFT SYSTEMS

Tom R. Cook, Maj, USAF | 433p | GE/EE/71-6
Advisor: Prof T. L. Regulinski | Lab Sponsor: AFFTC | AD 883202

This study was made to identify the underlying probability density function of maintenance man-hours per flying hour (MMH/FH) for aircraft systems. This is accomplished by processing data obtained from A–7D and C–5A aircraft and conducting the Kolmogorov–Smirnov test for goodness of fit of nine selected probability distributions. When the Kolmogorov–Smirnov test would not distinguish between two or more, the likelihood ratio test was used to select the most likely distribution. After the probability distribution is identified, it can be used to determine the confidence limits of the maintainability parameter, MMH/FH. The conclusion is that the log normal distribution energes as a relevant model for A–7D MMH/FH and that both the log normal and Weibull distributions are useful for modeling C–5A MMH/FH.

30 A NEW APPROACH TO THE SEQUENTIAL PRIME IMPLICANT FORM

David A. Young, LT, USCG | 74p | GE/EE/71-29
Advisor: Lt Col F. M. Brown | Lab Sponsor: AFCRL | AD 883209

The Sequential Prime Implicant Form (SPIF) is a function which characterizes a sequential switching network. It is re-examined here as representing a system of sequential Boolean equations. A special form of Boolean function, called a prime function, is related to realizable networks. A new and simpler method of eliminating variables from a Boolean equation is described. The application of the SPIF to certain questions of network decomposition, fault detection and diagnosis, network splicing and cutting, and transformation of state codes is presented. Conjectures on related research link the SPIF with automata theory, self repair theory, and machine synthesis.

31 PATTERN RECOGNITION MODEL BASED ON CORTICAL ANATOMY

Willis O. Mahaffey, Jr., 1st Lt, USAF | 120p | GE/EE/71-18
Advisor: Dr. M. Kabrisky | Lab Sponsor: AMRL | AD 722651

This report presents material supporting a model for pattern recognition that closely approximates the connectivity evident in the neurons of the cerebral cortex. A computer simulation of the model was tested on three sets of patterns (letters and geometric figures) and the results show that pattern separation is generally the same as for a human.

32 REGULAR EXPRESSIONS AND CHECKING EXPERIMENTS FOR SEQUENTIAL MACHINES

Wilfred L. Crossman, Capt, USAF | 73p | GE/EE/71-7
Advisor: Lt Col F. M. Brown | Lab Sponsor: AFCRL | AD 883438

This report presents a new method for designing checking experiments for sequential machines through the use of the algebra of regular expressions and graph theory. The class of sequential machines is restricted to those strongly-connected, reduced machines which have at least one distinguishing sequence. The class of detectable faults is restricted to those faults which do not occur intermittently, occur during conduction of the experiment, or cause an increase in the number of states. The experiment is divided into two parts--the homing portion and the checking portion (sequences). The homing sequence is designed by presently published methods. To design the checking sequence, a distinguishing sequence is chosen and added to the state table as an additional input column. The input successor graph is built from this augmented state table and a start state is chosen. Using knowledge of the operations of the algebra of regular expressions and the properties of the chosen, and other, distinguishing sequences for the machine, all unnecessary branches are removed from the graph. The graph is then solved by node reduction for the regular expression which defines all input sequences which will take the machine from the start state back to the start state. The regular expression is then reduced to an input sequence. It, and the corresponding output sequence, constitute a checking sequence for the given machine. Resulting checking sequences are considerably shorter in length than those designed by presently published methods.

33 RELIABILITY MODELING OF SPATIALLY AND TEMPORALLY REDUNDANT COMMUNICATION SYSTEMS

Jackson L. Hicks, Capt, USAF | 112p | GE/EE/71-13
Advisor: Prof T. L. Regulinski | Lab Sponsor: RADC | AD 883204

Models are proposed to quantify the system reliability for certain classes of communication systems subject to both spatial and temporal redundancy. Models are developed for both active and standby redundant configurations in which all elements are spatially identical, all channels are discrete binary burst-noise channels, and FEC is used. Element temporal reliability is evaluated from three commonly measured channel statistics. System reliability is then shown to be dependent on both temporal reliability and the number of system elements which are operational at time t. The models developed appear to be sufficiently general to permit quantification of system reliability for certain classes of actual communication systems.

34 SEQUENTIAL MACHINES AS MEMORY UNITS

David W. Stahl, LtCol, USAF | 75p | GE/EE/71-28
Advisor: Lt Col F. M. Brown | Lab Sponsor: AFCRL | AD 883208

A system of classifying synchronous sequential machines as memory units is presented. Methods of machine synthesis using the classified machine as a memory unit are detailed. The design of a synthesized control unit used is the solution to a Boolean equation and a simplified method to solve such an equation is presented and justified. A relationship of containment between machines is defined and an algorithm to determine if one machine is contained within another is developed. It is shown that any synchronous sequential machine can be classified as a memory unit, and that a universal memory unit of m states, where m is the number of strongly connected states within the classified machine, can be synthesized.

35 A STUDY OF AN AUTOMATIC LANDING SYSTEM WITH PROVISIONS FOR DECRAB

Harold L. Arner, Maj, USAF | 103p | GE/EE/71-3
Advisor: Col J. H. Blakelock | Lab Sponsor: AFFDL

The dynamics of glideslope and localizer tracking, exponential flare and decrab are studied to synthesize an automatic flight control system capable of providing for an automatic landing in the presence of crosswind. The existing autopilot of the C-141A aircraft is supplemented to provide this capability. Root-locus analysis is performed to determine system responses, and analog simulation of the system is conducted. The control equation for an exponential flare path is determined by specifying a nominal sink rate at touchdown. Decrab is achieved by establishing a constant sideslip which opposes the crosswind. Complete decrab is found to be limited by physical limitations on aileron deflection.

36 A STUDY OF SIMULTANEOUS SOLID–STATE DIFFUSION IN FABRICATION OF INTEGRATED CIRCUITS (FROM DOPED SILICAFILMS)

Alan A. Ross, Capt, USAF | 63p | GE/EE/71-24
Advisor: Prof J. Lubelfeld | Lab Sponsor: AFAL | AD 726553

This study explores three areas. The first is the use of doped silicafilms as diffusion sources. The second is the use of these silicafilm diffusion sources in simultaneous diffusion of N– and P–type regions. The third is the production of complementary insulated gate field effect transistors using silicafilm diffusion sources in a triple-diffusion process. The doped silicafilms were shown to be useful diffusion sources. The simultaneous diffusion was not achieved, and the conclusion is that even if simultaneous diffusion is possible using silicafilm sources, the gain would not be worth the effort. The triple-diffusion process worked well, and the resulting devices are discussed in the last part of the report.

37 COMPUTER RECOGNITION OF INDIVIDUAL WORDS IN CONTINUOUS SPEECH USING THE FOURIER TRANSFORM

Ronald W. Nath | GE/EE/71-21
Advisor: Dr. M. Kabrisky | Lab Sponsor: AMRL

The purpse of this investigation is to apply methods of pattern recognition, which use the Fourier transform and have been previously used for both visual and auditory pattern recognition, to continuous speech analysis. Continuous speech is filtered in a multiple band-pass device, recorded on a ten-channel tape, and digitized; the two-dimensional matrices are filtered and then classified by comparing them with a set of stored transform prototypes. Two methods of comparison are used; transform distance and correlation. Time and energy normalization are employed. The results show that classification of the individual words in continuous speech is possible.

38 THE EXTENDED KALMAN FILTER APPLIED TO THE DETERMINATION OF THE ORBITAL PARAMETERS OF A PASSIVE EARTH SATELLITE

Charles E. Rogers, Capt, USAF and Christo Christodoulou, Capt, USAF 63p GE/EE/71S-1
Advisor: Lt Col R. A. Hannen Lab Sponsor: ADC AD 730158

The extended Kalman filter is used to determine estimates of the orbital parameters, including drag, of a passive earth satellite. Actual tracking data from earth based radars were used and the orbital parameter estimates compared favorably with estimates obtained by other investigators using differential correction techniques. Also investigated was the utility of the extended Kalman filter for obtaining a sustained estimate of orbital parameters through several orbits with large data gaps and different radar site data for each orbit. The extended Kalman filter was not as effective under these circumstances, however, ad-hoc procedures were developed to sustain the estimate.

39 PSYCHOLOGICAL CORRELATES OF A MODEL OF THE HUMAN VISUAL SYSTEM

Arthur P. Ginsburg, 2nd Lt, USAF 116p GE/EE/71S-2
Advisor: Dr. M. Kabrisky Lab Sponsor: AMRL AD 731197

A model of the human visual system is investigated for psychological correlates. A priori hypotheses from the model concerned with human identification of defocused letters as well as identification of rotated letters have been validated with the computer model. Gestalt principles of similarity, proximity, closure, and figure-ground perception as well as geometric illusions are explained in terms of spatial filter bandwidth using the optics homolog. The experimental results have allowed postulates which extend the model by means of another cortical transform and a spatial filter shape which is also psychologically correlated. It is further postulated tht the human perceptual space is the image domain from spatially filtered transforms of object forms. It is concluded that the model provides a means of obtaining quantitative psychological correlates of the human visual system. Recommendations are made for additional investigations concerning psychological correlates.

40 TEMPERATURE AND FREQUENCY DEPENDENCE OF THE DIELECTRIC CONSTANT AND VOLUME CONDUCTIVITY OF PERCHLORO–P–XYLENE AND OCTACHLORO–P–XYLENE

Anthony Martinex III, Capt, USAF 201p GE/EE/71S-4
Advisor: Dr. R. E. Fontana Lab Sponsor: ARL AD 730151

An experimental study was conducted to determine the dipole moment and the frequency and temperature dependence of the dielectric constant, and volume conductivity of perchloro-p-xylene and octachloro-p-xylene, two recently synthesized organic compounds. A sample holder, suitable for liquid and solid specimens, was designed which allows the environment of the sample to be controlled. Three terminal, guarded measurements were conducted on solid samples of the compounds to determine the frequency and temperature dependence of the dielectric constant and the volume conductivity. The frequency and temperature ranges investigated were 100 Hz to 5 MHz and -70°C to 100°C, respectively. Polarization of the compounds was determined by measuring the variation of the dielectric constant and specific volume of solutions of the compounds and cyclohexane as a function of the weight fraction of the compound in solution. X-ray powder patterns were used to determine if anomalies in the temperature dependence of the volume conductivity were caused by structural changes in the crystal lattice. The dielectric constant of the compounds was determined to be frequency and temperature independent. The volume conductivity of the compounds was found to be dependent on frequency and temperature with anomalies noted at -20°C to 0°C for perchloro-p-xylene and at 30°C to 60°C for octachloro-p-xylene. The results of the x-ray powder patterns indicate that these anomalies are not due to first order transitions of the crystal lattice but may be caused by a small shift of the positions of the atoms in the unit cells.

41 EFFECT OF HIGH G FORCES ON THE VESTIBULO–OCULAR COUNTERROLL REFLEX OF RHESUS MONKEYS

Richard H. Wheeler, Capt, USAF 87p GE/EE/71S-5
Advisor: Capt C. N. Day Lab Sponsor: AMRL AD 730156

A model of the vestibulo-ocular reflex manifest by counterroll was used to determine the effects of high G forces on the response of the vestibular system of Rhesus monkeys. Baseline data for determining model parameters were generated prior to subjection to high Gs. After subjecting monkeys to high G, the tests were again run to determine if significant changes had occurred in the model's parameters. The tests consisted of constant speed rotation, pendular oscillations and multiple sine wave oscillations about their line-of-sight. Counterroll was recorded using a linear resolver mechanically fixed to the monkey's eyeball and the data collected analyzed by use of the fast Fourier transform. The results of this study indicate that the response is not significantly affected by G loading as high as 70G.

42 ANALYSIS OF THE FDL–8 LIFTING BODY LATERAL–DIRECTIONAL MODES AND PRELIMINARY DESIGN OF A STABILITY AUGMENTATION SYSTEM FOR SUBSONIC FLIGHT

Gat M. Chin, Capt, USAF — 146p — GGC/EE/71-4
Advisor: Maj J. E. Funk — Lab Sponsor: AFFDL — AD 730150

The problem was to determine if the FDL–8 manned re-entry vehicle lateral-directional modes have clearly adequate pilot handling qualities in subsonic flight. If not, a SAS was to be designed. Lateral characteristics for 21 subsonic flight conditions were obtained from linearized aircraft lateral equations. Assumptions were that symmetrical reference flight conditions and small-perturbation theory apply. The characteristics compared with requirements for highest level handling qualities showed a SAS was required. A two-loop SAS was designed using Root-Locus techniques. The yaw damper loops included undesirable Roll-Spiral coupling but the roll damper, second loop suppressed the Roll-Spiral coupling.

43 APPLICATION OF SELF–ADAPTIVE CONTROL TECHNIQUES IN THE DESIGN OF A NORMAL ACCELERATION CONTROL SYSTEM FOR A HIGH–PERFORMANCE SUPERSONIC AIRCRAFT

Richard R. Paul, Capt, USAF — 137p — GGC/EE/71-17
Advisor: Col J. H. Blakelock — Lab Sponsor: AFFDL — AD 730162

This thesis presents a design approach for a self-adaptive normal acceleration control system which is required for a hypothetical aerospace vehicle that operates throughout a wide range of Mach numbers and dynamic pressures. The control problem includes the realistic complications of undesirable structural modes, a nonlinear servoactuator, and the statistical nature of the aircraft stability derivatives and bending mode parameters. A systematic design procedure is developed which employs a servoactuator control loop with a variable gain, in addition to the conventional pitch-rate and normal acceleration control loops, both of which use constant loop gains. The control system is simulated on an analog computer and tested at each flight condition, where variation of the servoactuator loop gain is accomplished manually. At each individual flight condition, this gain is adjusted to the value that would have ordinarily been dictated by an Off-Line Adaptive Computer (OLAC), which uses elevator position and pitch-rate measurements from the aircraft to identify and compute changes in elevator effectiveness. Collective examination of the analog results reveals that the aircraft response to command inputs and wind gust disturbances meet the design specifications for the majority of the flight envelope.

44 A CLASSICAL DESIGN APPROACH TO A NORMAL ACCELERATION STABILITY AUGMENTATION SYSTEM FOR A HIGH PERFORMANCE AEROSPACE VEHICLE

Ralph R. Ward, Jr., 1st Lt, USAF — 91p — GGC/EE/71-25
Advisor: Col J. H. Blakelock — Lab Sponsor: AFFDL — AD 730152

This thesis represents a response to the design challenge problem presented at the 1970 Joint Automatic Control Conference. The design entailed a stability augmentation system for a high speed, high performance aerospace vehicle, including consideration of the first two structure modes. A normal acceleration system with a pitch rate inner loop was designed. Root locus techniques were used exclusively in obtaining an appropriate filter and fixed compensation in the pitch rate and normal acceleration loops. Relatively simple, but not large, gain changes in both loops was necessary to achieve the desired time responses to a commanded input. Realistic gust responses proved to be well within prescribed tolerances.

45 A COMPUTATIONAL COMPARISON OF GRADIENT MINIMIZATION ALGORITHMS

Craig E. Miller, 1st Lt, USAF — 132p — GGC/EE/71-16
Advisor: Maj J. E. Funk — Lab Sponsor: ARL — AD 730159

A technique was developed for the comparison of gradient minimization routines in solving the unconstrained optimization problem. The problem of locating the local minimum of a given real-valued, non-negative, differentiable function was used in this study to compare three gradient algorithms, namely Davidon's variance algorithm, the Fletcher–Reeves algorithm, and the Fletcher–Powell algorithm. A cost criterion and an average convergence rate were devised to facilitate the comparisons of these algorithms. Davidon's variance algorithm, a rank-one method, was judged to be the best routine for over fifty-three percent of the total cases tested. The comparisons are graphically presented in Appendix B.

6 THE DETERMINATION OF A GUNSHIP TRAJECTORY UNDER THE INFLUENCE OF A STEADY WIND

Robert T. Jones, 1st Lt, USAF — 84p — GGC/EE/71-11
Advisor: Prof J. J. D'Azzo — Lab Sponsor: AFFDL — AD 730154

The principle reason for the existence of the gunship results from the need to maintain gun to target alignment for an extended period of flight time. The determination of a closed loop trajectory of the initial slant range from target to aircraft for a given steady, horizontal wind velocity and an equation to represent that closed loop are the primary products of this report. The equations of motion of the aircraft

are developed then linearized about a nominal, no wind, solution. The important assumptions are; the wind encountered has a constant velocity, the aircraft maintains a constant altitude and airspeed and the yaw angle is assumed to be small at all times. Finally, an existing but fairly recent approach guidance scheme was modified for this particular problem to guide aircraft to the initial offset slant range for a given wind velocity. Upon reaching this point, the aircraft will be in the proper bank angle configuration eliminating the necessity for any violent maneuvering to attain initial gun alignment.

47 DESIGNING A CONTROL AUGMENTATION SYSTEM FOR THE H–53 HELICOPTER

Robert W. Radloff, Capt, USAF — 119p — GGC/EE/71-20
Advisor: Maj J. E. Funk — Lab Sponsor: AFFDL — AD 730160

This thesis presents the procedures used in designing a control augmentation system (CAS) for the H–53 helicopter. The conventional root locus design techniques, along with an analog computer simulation, were used to design the system. Two control loops were formed; the height rate control loop (collective pitch control) and the pitch control loop (cyclic pitch control). When both loops are closed the helicopter does not respond correctly to pitch commands. The problem of improper height response during pitch commands was solved by cross coupling some of the pitch command to the height control loop. The results show that a simple CAS is feasible and desirable to improve the controllability of present day helicopters.

48 IMPROVED AIRCRAFT MANEUVERABILITY BY ARTIFICIALLY STABILIZING A BASICALLY UNSTABLE AIRCRAFT

Fred L. Bryant, 1st Lt, USAF — 109p — GGC/EE/71-2
Advisor: Col J. H. Blakelock — Lab Sponsor: AFFDL

The purpose of this study was to show that the dynamic response characteristics of an aircraft can be improved by artificially stabilizing it after its center of gravity has been moved behind its aerodynamic center. By changing the feedback parameter in the inner loop, three different configurations of a pitch orientational control system were used to provide this stabilization. The types of feedback that were used were pitch-rate, angle-of-attack, and normal acceleration. The angle-of-attack feedback was able to stabilize and improve the response time of the aircraft in the inner loop. While the pitch-rate feedback and a combination of normal acceleration and pitch-rate feedback were unable to stabilize the inner loop, they were able to increase the response time. For this combination, the aircraft was then stabilized by the completion of the outer loop of the pitch orientational control system. Of the three types of feedback used, the combination of normal acceleration and pitch-rate feedback gave the fatest response time to a pitch-rate command. The study showed that the response time to a pitch-rate command of a controlled, basically unstable aircraft can be reduced to approximately one-fifth of the time that was required for a stable aircraft.

49 AN INVESTIGATION OF CROSS–COUPLING THE ELEVATORS AND THROTTLE SYSTEMS FOR THE KC–135 AIRCRAFT IN THE LANDING CONFIGURATION

Ronald E. Goodfellow, 1st Lt, USAF — 125p — GGC/EE/71-8
Advisor: Col J. H. Blakelock — Lab Sponsor: AFFDL — AD 730153

The purpose of this study was to investigate the possibility of using cross-coupling methods as additional controls during automatic landing approaches. This investigation was for aircraft that have the engine thrust line below the center of gravity of the aircraft. The KC–135 aircraft dynamics were used in this study. Three methods of cross-coupling were investigated. These methods were the cross-coupling of a thrust signal into the elevator system; the cross-coupling of the glide slope beam error signal into the engine system; and a combination of these two methods. This study showed that the pitch handling characteristics of the aircraft in the landing configuration were improved with all three of the methods investigated.

50 INVESTIGATION OF INPUT NOISE APPROXIMATIONS OF HUMAN RESPONSE MODELING

Paul F. Torrey, Capt, USAF — 68p — GGC/EE/71-24
Advisor: LtCol R. A. Hannen — Lab Sponsor: AFFDL — AD 730142

This study was conducted to investigate the validity of approximating random Gaussian-distributed inputs used in human response modeling by sums of discrete sinewaves. An ideal rectangular power density spectrum was simulated using both filtered Gaussian-white-noise and sums of discrete sinewaves. These two input spectra were used in the same compensatory tracking task, and the resultant normalized tracking error and qualitative operator observations were used to show that there were no apparent differences in the effects of the two types of input spectra. In addition, parameter tracking was used to collect frequency response data on the discrete rectangular input spectrum. This data showed that the operator adjusted his tracking as predicted by the adjustment rules of AFFDL–TR–65-15 (Ref 14) when there was negligible power in the operator's crossover region. Parameter tracking data obtained with a first-order-filter continuous input was shown to approximate the results obtained with other input spectra of both the continuous and discrete type, which contained power in the crossover region.

51 AN INVESTIGATION OF THE APPLICABILITY OF LINEAR OPTIMAL CONTROL THEORY TO AIRCRAFT CONTROL SYSTEM DESIGN

Ancel R. Sherrard, 2nd Lt, USAF | 131p | GGC/EE/71-22
Advisor: LtCol R. A. Hannen | Lab Sponsor: AFFDL | AD 722652

Using steady state linear regulator theory a longitudinal feedback control system is found for a hypothetical high-performance aircraft that operates through a wide range of Mach number and dynamic pressure. The aircraft stability derivitives vary statistically, and the aircraft measurement sensors are effected by body bending responses. Linear approximations of the optimal feedback law gains are programmed as functions of Mach number and dynamic pressure, and the normal-acceleration elevator-step-response of the closed-loop aircraft is simulated. The simulated step responses are compared to a normal acceleration step response criterion envelope that is specified in the 1970 Joint Automatic Control Conference (JACC) Design Challenge. In some regions of an arbitrary flight profile the rise time of the simulated step response is longer than the maximum allowed in the normal acceleration response criterion envelope;however, in all regions of the flight profile the peak overshoot of the simulated step response is well within the criterion envelope. Also, in all regions of the flight regime the wind gust response of the aircraft is well within the specifications set forth in the JACC Design Challenge.

52 OPTIMAL SELECTION OF STABILITY AUGMENTATION SYSTEM PARAMETERS TO REDUCE THE PILOT RATINGS FOR THE PITCH TRACKING TASK

Teddy L. Hollis, 1st Lt, USAF | 83p | GGC/EE/71-10
Advisor: LtCol R. A. Hannen | Lab Sponsor: AFFDL | AD 730143

A method for determining the optimal stability augmentation system (SAS) parameters for minimizing the pilot rating for the pitch tracking task is presented. The pilot rating prediction method is discussed. The Newton-Raphson method for finding the pilot parameters is introduced. The cost function used for finding the optima' SAS parameters is formulated to include SAS rate and deflection constraints. The optimization procedure is applied to the USAF/CAL T–33 variable stability airplane. Two different SAS configurations (pitch rate and pitch rate plus normal acceleration) are examined for six different flight conditions. The results show that the pilot rating predictions are reduced and a comparison with the military specifications show that the short period handling qualities are improved.

53 PRELIMINARY DESIGN OF AN ENERGY MANAGEMENT CONTROL SYSTEM FOR A HIGH PER–FORMANCE LIFTING BODY REENTRY VEHICLE

John W. Bunnell, 1st Lt, USAF | 85p | GGC/EE/71-3
Advisor: Maj J. E. Funk | Lab Sponsor: AFFDL | AD 730155

A preliminary design was developed for the guidance and phugoid damping portions of an energy management system to be used aboard a lifting body with a hypersonic L/D near 3.0, during the atmospheric maneuvering phase of reentry. A three-degree-of-freedom simulation was derived, using range angle, cross-range angle and radius as state variables. The guidance scheme considered was based on a fast-time predicition of the footprint and nominal trajectory by numerical integration of the equations of motion. Temperature constraints, maximum heating rates and structural limits were neglected.

54 SOFTWARE SYSTEMS FOR HYBRID COMPUTERS

Douglas B. Hardie, 1st Lt, USAF | 106p | GGC/EE/71-9
Advisor: Prof C. W. Richard, Jr. | Lab Sponsor: ASD | AD 724618

An existing real-time operating system is used as the basis for a nybrid system. The additional facilities required were included in the system as new processors. None of the features in the original system are altered, but new ones are created. Thus, the augmented system is compatible with new releases of the original system. Since the new processors provide a new level of control between the user and the original system, the augmented system can be made to look totally different to the user. Hence, a complex system can be given a sample interface with the user for a small class of similar problems. Additionally, an investigation is made into the practicality of adapting digital simulation language to hybrid computation. The techniques used in digital simulation languages can be extended to provide all the information necessary for hybrid simulation. A proposed hybrid system is developed from these techniques. Such a system would allow the user to communicate with the computer in the language of the problem, and not require him to be an experienced programmer.

55 A STUDY OF GUIDANCE SCHEMES FOR AIR–TO–AIR MISSILES

John R. Stewart, 1st Lt, USAF | 72p | GGC/EE/71-21
Advisor: Maj D. H. deDoes | Lab Sponsor: AFAL | AD 730161

A number of guidance laws which may be used in an air-to-air homing missile are presented. Primary emphasis is given to forms which use proportional navigation augmented by line of sight acceleration. It is concluded that the addition of the line of sight acceleration to proportional navigation does not significantly improve the terminal accuracy of homing missiles.

56 A STUDY OF THE LATERAL HANDLING QUALITIES AND STABILITY AUGMENTATION REQUIREMENTS OF A HEAVY STOL TRANSPORT IN LOW SPEED FLIGHT

Garth P. Corey, 1st Lt, USAF | 99p | GGC/EE/71-5
Advisor: Maj D. H. deDoes | Lab Sponsor: AFFDL

Handling qualities and stability augmentation requirements are determined for the lateral-directional dynamic response of a heavy jet STOL transport at slow cruise and landing velocities. Theoretical development of the open loop aircraft response indicates a highly unstable spiral mode and lightly damped dutch roll mode. Root locus design techniques are applied in the development of a satisfactory stability augmentation system to improve the dynamic response and subsequent handling qualities of the aircraft. Results indicate compensation is required for satisfactory handling qualities and increased aerodynamic control at low velocities is imperative for a fully operational heavy jet STOL transport.

57 A STUDY OF THE PRACTICALITY OF ACTIVE VIBRATION ISOLATION APPLIED TO AIRCRAFT DURING THE TAXI CONDITIONS

Charles D. Corsetti, 1st Lt, USAF | 160p | GGC/EE/71-6
Advisor: Lt Col R. A. Hannen | Lab Sponsor: AFFDL | AD 730141

The feasibility of using an active control in the landing gear system of an aircraft to reduce wing fatigue damage resulting from ground induced vibrations during taxiing is considered. The characteristics of three vehicle models are discussed: a single landing gear system, a tricycle landing gear system, and a system of five landing gears. Mathematical expressions for the runway inputs to each vehicle model are obtained in the form of random inputs represented by Gauss-Markov processes. The model for a linear hydraulic actuator which is used as the active control element in the landing gear system is presented. The approach used in the study is to determine an optimal control law which is a proportional feedback of the measurements. The measurements, in turn, are assumed to be both a linear transformation of the states and noiseless. The feedback gains in the optimal control law are obtained in such a way as to minimize a cost criterion, which is a measure of the controller's ability to reduce wing fatigue resulting from runway imposed vibrations. The methodology for obtaining the optimal solution for the given cost criterion is developed and solutions for the three different models and for various measurement schemes are obtained. The results indicate that the combined optimal active control and landing gear system can provide a substantial improvement in reducing wing fatigue over that of the landing gear system alone. Also, the control parameters that are necessary and desirable in the optimal system, together with the physical demands placed on the actuator, are determined.

58 VERIFICATION AND EXTENSION OF DISPLAY SCANNING AND REMNANT MODELS USING AIRCRAFT LATERAL AND LONGITUDINAL DYNAMICS AS CONTROLLED ELEMENTS

Luis A. Machuca, 1st Lt, USAF and James M. Lind, 1st Lt, USAF | 235p | GGC/EE/71-14
Advisor: Prof J. J. D'Azzo | Lab Sponsor: AFFDL | AD 730154

An investigation of theoretical models of the human operator's scanning behavior and tracking performance while simultaneously controlling two closed-loop tasks using separate displays is undertaken. Two different two-display compensatory tracking situations are tested. The first uses transfer functions of K/s and K/(s-1) as controlled elements, and the resulting data is compared with that previously obtained by Systems Technology, Incorporated (STI) under similar experimental conditions. The second uses the longitudinal and lateral dynamics of the F–4 as primary and secondary controlled elements, respectively, with a white noise input forcing function simulating a wind gust disturbance of selected bandwidths. Differences in the subject's scanning behavior, remnant, and tracking performance are noted for these two tracking situations. Scanning statistics show that pilots may adopt different average scanning and sampling strategies, and it is verified that the adjustable quasi-linear describing functions and remnant model proposed by STI do accurately predict the pilot's tracking performance under certain circumstances. It is shown that the pilot adjusts his scanning strategy in response to the tracking situation and that proposed "scanning parameters" may not accurately predict these changes. Possible mental processes for reconstruction are investigated and a "weighted average" form of reconstruction is outlined.

59 FREQUENCY DOMAIN ANALYSIS AND STATISTICAL STUDY OF PSEUDO–RANDOM BINARY SEQUENCES USED FOR MODULATION CODING

Charles W. Baker, 1st Lt, USAF | 87p | GGC/EE/71-1
Advisor: Capt J. A. Neff | Lab Sponsor: RADC

During the past decade, there has been an enormous change in the concepts of radar signal analysis. With power constraints on the transmitter, sophisticated concepts and principles were applied to the receiver systems. One of these methods is the use of pseudo-random sequences for modulation and subsequent correlation in the receiver system. This study uses Discrete Fourier Transform analysis with the Fast Fourier Transform to determine the clockrate and/or length of the sequences. It is shown by using the FFT, that maximal length sequences can be separated from the non-maximal sequences. It is shown that the sequence length can be determined and then separated by the use of the Euclidean distance measure even in the presence of additive Gaussian noise.

60 DESIGN OF A HELICOPTER STABILITY AND CONTROL AUGMENTATION SYSTEM USING OPTIMAL CONTROL THEORY

Alvin R. Lang, Lt, USAF | 99p | GGC/EE/71-13
Advisor: Major J. E. Funk | Lab Sponsor: AFFDL | AD 732911

This thesis presents the design of a helicopter stability and control augmentation system using optimal control techniques. The helicopter used as an example was the Sikorsky H–53, but the design procedure is applicable to other helicopters as well. Only the longitudinal dynamics are considered. A technique is described for the design of multivariable feedback controllers based upon results in optimal control theory. For a specified performance index the feedback controller is obtained by solving the matrix Riccati equation. A model is used in the forward controller such that the response of the model to pilot inputs approximates the desired helicopter response. A fixed gain controller is obtained which may be used over the entire helicopter flight envelope. The results show that optimal control theory can be used to design a helicopter stability and control augmentation system. Responses obtained may be classified as those which are desirable and yield good handling qualities.

61 THE SYNTHESIS OF MULTIPOINT QUASI–OPTIMAL FEEDBACK CONTROL LAWS FOR NON–LINEAR SYSTEMS VIA MINIMUM SENSITIVE TRAJECTORIES

Morris C. Lowe, Lt, USAF | 95p | GGC/EE/71-15
Advisor: Major D. H. deDoes | Lab Sponsor: FJSRL | AD 732933

This thesis considers a multipoint quasi-optimal feedback control law which makes use of multiple optimal state and control histories to generate a set of feedback coefficients that are functions of the system's independent variable. The feedback coefficients are used, in conjunction with both the system's states and independent variable, to generate a linear quasi-optimal feedback control law for controlling a non-linear dynamic system. A family of quasi-optimal feedback control laws is obtained for an aircraft landing problem in which the trajectories and control histories, used to synthesize the control laws, are obtained from solutions of optimal control problems reflecting minimization of the system's sensitivity coefficients. In this study, sensitivity coefficients are defined as mathematical descriptors that relate changes in the system's states at any time t to errors in the terminal state at the final time t_f.

62 ELASTIC MODULI OF MULTIDIRECTIONALLY FIBER–REINFORCED COMPOSITES

David J. White, Capt, USAF | 71p | GNE/PH/71-6
Advisor:Lt Col D. M. Ericson, Jr. | Lab Sponsor: AFML

A laminate maodel is presented for predicting the elastic stiffness coefficients of a multidirectionally fiber-reinforced composite as a function of the elastic properties and volume fractions of the constituents. The number of layers in the model corresponds to the number of different fiber orientations within the composite and the thickness of each layer is proportional to the volume fraction of fibers in the orientation which that particular layer represents. The effects of voids in the matrix are accounted for. Explicit expressions are derived to calculate the stiffness coefficients for an N–layered laminate whose layers contain fibers in the plane or perpendicular to the plane of the layers. Sample calculations are shown and predictions of elastic moduli are compared to data available in the literature for several typical composites.

63 HIGH TEMPERATURE ANNEALING OF PHOTOLUMINESCENSE BANDS IN IRRADIATED GERMANIUM

Raymond J. Burek, 1st Lt, USAF | 83p | GNE/PH/71-2
Advisor: Dr. R. L. Hengehold | Lab Sponsor: AFML | AD 726993

The isochronal annealing behavior, between 20°C and 420°C, of radiation defects in cobalt–60 irradiated germanium was studied by photoluminescence. Spectra were recorded at liquid helium temperature for each 50°C annealing interval, and relative intensity vs annealing temperature curves were plotted for prominent defect bands. The annealing behavior of a 0.688eV zero-phonon line formed during room temperature

irradiation suggests that it may be associated with the germanium A–center. New Mossbauer-type spectra with zero-phonon lines located at 0.686, 0.699, and 0.722eV appeared after annealing at 170°C. Four bands believed to be caused by recombination at dislocations were also observed at 0.511, 0.518, 0.529, and 0.57eV.

64 INTRODUCTION TO THE ELECTROMAGNETIC PULSE

Otho V. Kinsley, Maj, USAF — 200p — GNE/PH/71-4
Advisor: Dr. C. J. Bridgman — Lab Sponsor: AFWL — AD 726994

This thesis constitutes an introductory survey of the electromagnetic pulse (EMP) caused by a nuclear weapon burst. The survey is separated into (1) driving mechanism, (2) the electric field of the symmetric nuclear burst, (3) the electromagnetic field from bursts whose environment is asymmetric due to density variations of the geomagnetic field's presence, (4) pulse transmission, and (5) pulse interaction. This survey was collected from the unclassified literature and is presented here in a consistent notation and language. The presentation is intended to emphasize concepts and understanding and is not intended as a design handbook. To this end the author has attempted some mathematical simplification of certain phenomena. These simplified models are identified when employed and the results obtained are compared to those found in the literature which result from test data or from more exact mathematical models.

65 AN INVESTIGATION OF A MIXED–PHASE EQUATION OF STATE FOR THE PUFF 66 COMPUTER CODE

William H. Barrett, Capt, USAF — 115p — GNE/PH/71-1
Advisor: Lt Col D. M. Ericson, Jr. — Lab Sponsor: AFML — AD 726992

A mixed-phase equation of state was programmed for the PUFF material response code and the behavior of 2024 aluminum was investigated. Identical PUFF problems were run on the CDC 6600 computer at the Air Force Weapons Laboratory to compare the existing and mixed-phase equations of state. The mixed-phase formulation is a more realistic representation of the response of materials to nuclear radiation, but it predicts responses qualitatively similar to those predicted by the existing equation of state. Based on the limited nature of the investigations, it was concluded that the mixed-phase equation of state should not replace the existing one.

66 THEORY, ASSEMBLY, AND CALIBRATION OF A NEUTRON TIME–OF–FLIGHT SPECTROMETER

Martin D. Centala, Maj, USAF — 136p — GNE/PH/71-3
Advisor: Dr. G. R. Hagee — Lab Sponsor: ARL

The theory, assembly, alignment, and initial calibration of a neutron time-of-flight spectrometer are discussed. The main detector system of the spectrometer consists of an organic phosphor (NE–213) and a fast photomultiplier (AMPEREX XP–1040). Problems encountered during the assembly and the calibration of the spectrometer are discussed. A rigorous checkout of the pulse-shape discrimination system was performed, using a multichannel analyzer and a radioactive source. Several photographs were taken of the oscilloscope traces of the electronic signals originating in the system. These were then compared with the expected signals and any discrepancies were resolved or traced.

67 THE ABSOLUTE OSCILLATOR STRENGTHS OF THE PBI LINES λ2833, λ3639, λ3683, and λ4057 BY THE METHOD OF TOTAL ABSORPTION

William F. Grof, Capt, USAF — 43p — GEP/PH/71-9
Advisor: Dr. L. S. Pedrotti — Lab Sponsor: ARL — AD 726987

The oscillator strengths of PBI for λ2833, λ2873, λ3639, λ3683, and λ4057 were measured by the method of total absorption. Radiation was passed through lead vapor of a known temperature. A 6–meter spectrograph was used to photograph the absorption lines. This data along with lead vapor pressure data yielded the f-values. The f-values found agreed well with those found by other laboratories. Due to systematic errors, there was a 10% uncertainty in the average f-values of each line. The standard deviation of the 16 samples of each line was less than 10%.

68 APPARATUS FOR STUDYING THE DECAY OF CATHODOLUMINESCENCE

William M. Carra, Capt, USAF — 52p — GEP/PH/71-3
Advisor: Dr. R. L. Hengehold — Lab Sponsor: ARL

An electron-beam excitation system was constructed to investigate the optical properties of the II–VI compounds. A narrow-angle triode type of electron gun operating at 13 kV was used to stimulate a sample held at 77°K. The gun was pulsed and the optical output sampled with a boxcar integrator. Experimental results indicated system performance substantially as expected. System design was such that other electron guns and potentials in excess of 30 kV may be used to investigate semiconductor lasing.

69 CORRELATION OF NEUTRON PRODUCTION TO X-RAYS AND VISIBLE LIGHT IN A DENSE PLASMA FOCUS

Craig M. Lee, 1st Lt, USAF | 78p | GEP/PH/71-12
Advisor: Dr. G. K. Soper | Lab Sponsor: SAMSO

Characteristics of neutron production from a 16–27 kJ plasma focus device were systematically studied for device parameters of bank energy, gas pressure, gas impurities and anode geometry. Neutron yields of 10^9–10^{10} per discharge were obtained with deuterium. Comparison of neutron and hard X-ray production was made using photomultiplier-plastic scintillator detectors. The axial neutron distribution was determined using a paraffin-polyethelene collimator. A good time correlation between the hard X-rays and the neutrons was observed. The dependence of the axial neutron source distribution on pressure was obtained and related to the shape of the collapsing plasma boundary.

70 AN EXPERIMENTAL EVALUATION OF THEORETICAL SOLAR FLARE MODELS

Robert C. Backstrom, 1st Lt, USAF | 125p | GEP/PH/71-1
Advisor: Lt Col C. J. Freyer | Lab Sponsor: SAMSO

A compilation, classification, and experimental evaluation of theoretical solar flare models published between 1947 and 1969 is discussed. The models are described and classified according to the flare energy source. Longitudinal magnetic field, hydrogen-alpha filtergram, 3-mm radio, 10-cm radio, and 0.06–2A^o x-ray data taken on three flares are described and used to evaluate the models by comparing predicted and observed phenomena. Two parallel flare brightenings are found in regions of high magnetic field strength on either side of a neutral-line filament. Hyder's gravitational infall-impact and Sturrock's Y-type coronal sheet pinch theories are found to best explain the flares.

71 FINITE PLASMA EFFECTS OF A MAGNETIZED PLASMA

Ronald C. Dykman, Capt, USAF | 40p | GEP/PH/71-4
Advisor: Dr. G. K. Soper | Lab Sponsor: ARL

Attempts are made to Fourier-Laplace analyze the linearized Boltzmann-Vlasov equations for an inhomogeneous plasma represented by a finite and bounded density distribution function. The problem is concluded to be too complex for solution at the Masters' thesis level.

72 FLUORESCENCE PROPERTIES OF GLASS: Nd AND YAG: Nd AT 1.06 MICRONS AS A FUNCTION OF TEMPERATURE

Jeffrey P. Johnson, Capt, USAF | 48p | GEP/PH/71-10
Advisor: Maj K. C. Jungling | Lab Sponsor: AFWL

Fluorescence properties of glass: Nd and YAG: Nd were investigated as a function of temperature. The glass: Nd was Owens-Illinois ED–2 doped with 3.0 atomic percent Nd^{3+}, and the YAG: Nd, with 1.2 atomic percent was from Airtron Corp. Measurements were made of the change in fluorescence peak intensity with temperature, and the relative fluorescence efficiency at 80, 140, and 200 deg C.

73 LANGMUIR PROBE DIAGNOSTICS IN THE ELMAX PLASMA DEVICE

James R. Nunn, Capt, USAF | 97p | GEP/PH/71-14
Advisor: Dr. G. K. Soper | Lab Sponsor: ARL | AD 726990

Cylindrical Langmuir probes were used to determine quiescent plasma conditions and instability thresholds in a mirror geometry magnetoplasma experiment (ELMAX). Radial profiles of electron temperature, density and velocity distribution were measured in an argon plasma maintained by two magnetic annular arc sources. A digital data recording system was devised which facilitated reduction of the probe curves with a computer program using collisionless probe theory. For magnetic fields below 400 gauss the peak values of electron temperature and density were 4×10^4 °K and 10^{13} cm^{-3}, respectively, and obversed density oscillations were less than 5%.

74 MEASUREMENT OF A VISIBLE REFLECTANCE SPECTRA OF ORBITING SATELLITES

John V. Lambert, Capt, USAF | 63p | GEP/PH/71-11
Advisor: Dr. L. S. Pedrotti | Lab Sponsor: ARL | AD 726988

Low resolution reflectance spectra of three orbiting satellites, objects 2253, 3819, and 4392, were measured using a scanning spectrometer designed and built for use with the Aerospace Research Laboratories satellite tracking telescope. The spectrometer, having a variable bandpass interference filter as the dispersive element, operates between 4000 and 7000 A^o with a resolution of 150 A^o. The required data reduction procedures were developed and the system was tested on astronomical objects. The measured reflectance spectrum of object 2253 is in agreement with that of the known surface material, aluminum. The measured reflectance spectra of objects 3819 and 4392 resemble those of white paints.

75 METHODS OF PHOTOPEAK ANALYSIS FOR GAMMA-RAY SPECTRA

Larry S. Blackwelder, 1st Lt, USAF — 89p — GEP/PH/71-2
Advisor: Dr. G. John — Lab Sponsor: ARL

Of concern in scintillation spectrometry has been the reduction of spectral data. If interest is restricted to energies and intensities, the reduction can be done through photopeak analysis. This includes four operations: preparation of data, peak search, subtraction of background, and determination of energy and intensity. An evaluation of SAMPO, a computer program designed to analyze spectral data, is presented along with a summary of the best methods of analysis available.

76 MOSSBAUER STUDY OF THE MAGNETOCRYSTALLINE ANISOTROPY OF $NdCo_5$

Carl D. Towery, Capt, USAF — 110p — GEP/PH/71-18
Advisor: Dr. G. John — Lab Sponsor: AFML — AD 726991

This project was initiated to determine if Mossbauer spectrometry can be used to monitor manufacturing processes of permanent magnets made of rare earth-3d transition element compounds. Mossbauer spectra were obtained with absorbers made of powdered $NdCo_5$ alloyed with Fe57. These spectra were obtained at four different temperatures in a range over which a 90 degree rotation of the magnetic axis of $NdCo_5$ is known to occur. The spectra were complex and changed significantly as temperature changed. The number of absorption peaks in each of the spectra indicates that Fe57 may enter three non-equivalent crystal lattice sites in $NdCo_5$.

77 NUCLEAR MAGNETIC RESONANCE STUDY OF CADMIUM SELENIDE AND CADMIUM TELLURIDE

Donald L. Moore, Capt, USAF — 83p — GEP/PH/71-13
Advisor: Dr. D. G. Shankland — Lab Sponsor: ARL — AD 726989

Knight shift and spin-lattice relaxation time has been measured for Cd^{113} nuclei in In-doped CdTe. From the Korringa product and the sign of the Knight shift, the electron g-factor has been calculated to be $g = 1.2 \pm .1$, which is a factor of three greater than that previously reported from theoretical estimates. Spin-lattice relaxation is due to contact hyperfine interactions. Degenerate and non-degenerate theory was applied to calculate the atomic volume normalized electronic probability density $< / \Psi F^{(o)} / ^2 > = 1.0 \pm 1 \times 10^{26}\ cm^{-3}$ and the hyperfine constant, $A_H = .31 \pm .03 cm^{-1}$. The CdSe experimental data indicated material constants, a factor of three greater than known values; therefore, the results are inconclusive.

78 PHOTOEMISSION STUDIES OF SEMICONDUCTOR BAND STRUCTURE

Paul Freedman, Capt, USAF — 76p — GEP/PH/71-8
Advisor: Dr. R. L. Hengehold — Lab Sponsor: ARL

Equipment was assembled for photoemission studies of semiconductor band structure; operating on the principles of ac retarding potential and the small signal conductance of photodiodes with semiconductor emitters. The data output was X-Y plot of the energy distribution of photoemitted electrons. The equipment was tested by observing the band structure of cadmium sulfide (CdS). CdS photoemission energy distribution curves (EDC) were taken for various photon energies below 11.6 eV. These were compared with curves obtained by other investigators using similar methods. The curves agreed very well which indicates the equipment assembled for this study is useful for further research.

79 THE RELATION BETWEEN VELOCITY FIELDS AND MAGNETIC FIELDS IN SUNSPOT REGIONS

Lloyd B. Young, Capt, USAF — 64p — GEP/PH/71-20
Advisor: Lt Col C. J. Freyer — Lab Sponsor: CRL

Simultaneous velocity field and magnetic field data for a complex sunspot group was obtained with a magnetograph using the Fe I line 5250.2 A^o. The relationship between the velocity field, magnetic field, and sunspot separation were investigated. Using the magnetic field as a source function, a model was developed that partially predicted the velocity field. The observed velocities were found to be primarily along the fieldlines, thus substantiating current theoretical predictions. Good correlation was found between the Evershed effect and proper motion by assuming the flow was 50%-75% effecient at causing sunspot separation.

80 THE SOLUTION OF MIXED BOUNDARY VALUE PROBLEMS USING NUMERICAL GREEN'S FUNCTIONS

Thomas Y. Edwards, Capt, USAF | 65p | GEP/PH/71-5
Advisor: Dr. B. Kaplan | Lab Sponsor: ARL | AD 726985

The solution by numerical Green's functions of Poisson's equation with mixed boundary conditions was examined. The differential equation in one and two dimensions was also solved by conventional numerical techniques, and solution time and accuracy of the two numerical methods were compared against analytical solutions with the aid of a computer. The results of the study indicate that the use of numerically determined Green's functions can be advantageous over conventional numerical techniques if certain restrictions are observed.

81 STUDY OF THE INTERNAL CONVERSION SPECTRUM OF Ra^{223}

Angel E. Rodriguez, 1st Lt, USAF | 70p | GEP/PH/71-15
Advisor: Dr. G. R. Hagee | Lab Sponsor: ARL

The internal conversion electron spectrum of Ra^{223} was investigated from about 90 kev to about 750 kev with a double-focussing magnetic spectrometer. Data was obtained on the 110.8, 122.3, 144.2, 154.2, 158.6, 179.7, 251.7, 269.4, 288.4, 323.9, 328.5, 333.9, 338.3, 342.9, 371.6, 444.9, 527.0 and 598.5 kev transitions in Rn, and the Po 271.2 T1 351, Po 401.8, Bi 404.1, Bi 427.0, Pb 438.8 and Bi 831.9 kev transitions. Based on the Rn data, possible spin/parity assignments of $(7/2^-)$, $(1/2, 7/2 \text{ or } 9/2^+)$, $(3/2, 5/2 \text{ or } 7/2^+)$, $(3/2 \text{ or } 5/2^-)$ and $(3/2^+)$ are suggested for the 598.5, 594.6, 541.4, 342.9 and 338.3 kev levels in Rn^{219}, respectively.

82 A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF LANGMUIR PROBES IN A HELIUM DISCHARGE

Willard J. Ekman, Capt, USAF | 44p | GEP/PH/71-7
Advisor: Col E. L. Battle | Lab Sponsor: AFAL | AD 726986

The Langmuir probe theories of Self and Shih, Waymouth, and Kiel for collisional plasmas are examined theoretically. A probe theory for a collision dominated plasma with a collision dominated probe sheath is presented. Spherical probe measurements were made in a hot cathode helium discharge at 0.3 and 0.4 Torr. Good agreement on the ion densities between the Self and Shih method and a method suggested by Medicus was obtained. The Medicus method gave better agreement with second derivative techniques on the determination of plasma potential than the Self and Shih method.

83 DESIGN ANALYSIS AND TEST OF FLUIDIC COMMUNICATION COMPONENTS

Robert J. Knowles, Jr., 1st Lt, USAF | 73p | GAW/ME/71-3
Advisor: Dr. M. E. Franke | Lab Sponsor: AFPL

A fluidic communication system using turbulent two dimensional flow as an operating medium was constructed. Input signals were amplified by means of amplitude modulation. Transmission lines of plastic tubing were used to transmit the modulated signal to the demodulation section. The inherent stability of a two dimensional jet was used to provide a means of demodulation. Results reveal that modulation is successful if the input signal has a sound amplitude of at least 12% of the sound amplitude of the carrier frequency. The demodulator did not respond as predicted to the carrier frequency produced by the fluidic oscillators and thus did not demodulate the input frequencies with the degree of clarity as would be thought possible.

84 DIFFUSION OF COBALT AND CHROMIUM IN COBALT OXIDE AND NICKEL OXIDE COMPACTS

Mark H. Davis, 2nd Lt, USAF | 58p | GAW/MC/71-6
Advisor: Capt W. B. Crow | Lab Sponsor: ARL

Diffusion studies were made for Cr^{51} diffusion in single crystals of NiO and CoO and for Co^{60} and Cr^{51} in compacted NiO and CoO. An improved Gruzin method was used to analyze the data. Measurements were made at temperatures between 977°C and 1243°C at an oxygen partial pressure of 1 atm. Due to chromium evaporation losses no equations were developed for single crystal diffusion. A discussion of the evaporation problem was given. The diffusion of the chromium in the compacted oxides did not fit the theoretical equations. The diffusion of cobalt followed the theoretical development, and the diffusion coefficients for cobalt could be represented as $D_{Co/CoO} = 2.5 \times 10^{-4} \exp(-26{,}800/RT) cm^2/sec$ $D_{Co/NiO} = 3.22 \times 10^{-4} \exp(-30{,}000/RT) cm^2/sec$.

85 THE DYNAMIC RESPONSE OF FLUIDIC NETWORKS

Alex J. Malanowski, 1st Lt, USAF — 81p — GAW/ME/71-2
Advisor: Dr. M. E. Franke — Lab Sponsor: AFFDL — AD 882871

The dynamic response of branched pneumatic transmission lines of circular cross section is investigated experimentally in the 40–1200 Hz frequency range and the results compared with theory. All cases consisted of a 0.189 inch ID main line with either a 0.032 or 0.093 inch ID branched line connected to the main line at an angle of 45^{o}, 90^{o}, or 135^{o}. Blocked lines with no flow and orifice ended lines with a mean flow were used. Four end line terminations were possible: both main and branch blocked; main open, branch blocked; main blocked, branch open; and both main and branch open. The lines were tested at pressures from 2 psig to 11 psig. Comparison of experimental and theoretical results was made with a computer program using Nichols' equations as modified by Krishnaiyer and Lechner. Except for a few isolated data points, the experimental transfer gain for blocked lines was predicted within 2 db by theory. For the orifice terminated lines, agreement of theory and experiment was within experimental accuracy limits (2–5 db). In all cases where measurement by themonitoring equipment was possible, phase angle readings were taken.

86 THE EFFECTS OF GRAIN DISTRIBUTION ON INITIATION AND PROPAGATION OF FATIGUE CRACKS IN 7075–T6 ALUMINUM ALLOY SHEET

James M. Schwindle, Capt, USAF — 68p — GAW/MC/71-12
Advisor: Major C. D. Stuber — Lab Sponsor: AFFDL

A study was made to determine a mechanism for initiation and propagation of fatigue cracks in 7075–T6 Alclad aluminum alloy sheet specimens subjected to cyclic tensile stresses. The applied stresses varied from a minimum of 79% to a maximum of 96% of the ultimate tensile strength. Fatigue fracture modes observed with the scanning electron microscope and a light microscope were compared to photomicrographs of polished and etched fracture surfaces of both laboratory and service failures. It was found that fatigue cracks always initiated between grain boundaries of grain fibers which extended to the surface of specimens. Fatigue cracks propagated transgranularly in a direction 90^{o} to the tensile stress direction, regardless of the angle by which specimens were cut with respect to the rolling direction of the sheet. Fatigue crack topography exhibited primarily brittle, and then ductile fatigue striations in the first and second halves of the fatigue crack area, respectively. Laboratory failures did not exhibit crack morphology similar to that of service failures. It is believed that significant improvements in fatigue resistance could be obtained in specimens having reduced grain size and regular distribution of grain fibers in a direction parallel to the tensile stress direction.

87 FRICTION AND WEAR CHARACTERISTICS OF ELASTOMER, ELASTOMER–METAL COMPOSITES ON CONCRETE

Thomas R. Meyers, Maj, USAF — 96p — GAW/MC/71-2
Advisor: Major C. D. Stuber — Lab Sponsor: AFFDL

Elastomer and elastomer-steel composites were selected and tested as possible materials for application in the braking system of the Air Cushion Landing Gear. Experimental equipment included a rotating concrete wheel to simulate the runway, various elastomer skids and the necessary instrumentation. The three elastomer materials used were Butyl, Viton–B, and Ethylene–Propylene Terpolymer (EPT). Tests were conducted at velocities up to 60 mph with contact pressures of 3, 5, and 7 psi. EPT proved to have the greatest potential as a brake skid material. Metal reinforcers in the form of rods and plates did afford some improvement in wear resistance without adversely affecting the coefficient of friction, provided that the additive was held to less than 3 percent by volume. Additional improvements were found in additives having higher strength. The coefficient of friction decreased with increasing velocity from an average value of 0.90 at 10 mph to a value of 0.55 at 50 mph. Wear rates increased with increases in velocity and contact pressure from an average value of 15 mills/1000 ft. at 5 psi and 10 mph to a value of 25 mills/1000 ft. at 5 psi and 50 mph. Finally, the steady state surface temperature for the EPT was low enough at all speeds below 60 mph to eliminate the problem of degradation of the material. It can be concluded that EPT or an EPT–Steel composite would function satisfactorily as a possible brake material in the Air Cushion Landing Gear.

88 GEOMETRIC EFFECTS ON THE PERFORMANCE CHARACTERISTICS OF VERY SMALL NOZZLES

Karl J. Jindra, 2nd Lt, USAF — 38p — GAW/ME/71-1
Advisor: Dr. W. C. Elrod — Lab Sponsor: AFPL

Pressure measurements and schlieren photographs were used to analyze the performance characteristics of very small (nozzles with a throat dimension less than 0.045 in.), 2–D, supersonic nozzles. The nozzle configurations had diverging wall angles between 5^{o} and 30^{o}, and nozzle lengths between 0.126 in. and 0.835 in. Each configuration was tested at throad dimensions of 0.045 in., 0.030 in., 0.015 in., and 0.007 in. All test runs were made with the p_C/Pa ratio equal to 100. The limit on smallness was determined to be a critical throat dimension near 0.015 in. Near and below this throat size conventional equations fail to suitably predict performance characteristics. Boundary layer growth seems to be closely related to the limit on smallness. Diverging wall angle has a greater effect on performance than does the nozzle length for all conditions investigated.

89 AN INVESTIGATION OF AAA OPTICAL TRACKING MODELS

James H. Thomas, Civ — 108p — GAW/MC/71-1
Advisor: Major Goldberg — Lab Sponsor: ASD

Optical tracking and aiming error equations as given by the Pen-Square and Lockheed-Eglin survivability models are compared. The Pen-Square computer program is used with both sets of equations to investigate the effects of the aiming equations on survivability calculations. A dynamic tracking model which models the tracker as a discrete-sampling, linear feedback element, is derived and investigated. Survivabilities and tracking errors generated by the tracking model are compared to experimental and the Pen-Square and Lockheed-Eglin results. Investigation shows that the different tracking equations result in large differences in survivability magnitudes and trends as computed by the various models. The dynamic tracking model generates tracking errors which are similar to those resulting from simulator experiments, but different from the actual tracking error data presented by Joint Task Force Two.

90 AN INVESTIGATION OF FORCES ON A PROJECTILE DURING PERFORATION OF THIN ALUMINUM PLATES

Visi Arajs, Capt, USAF — 98p — GAW/MC/71-3
Advisor: Major Goldberg — Lab Sponsor: AFML

The reverse forces encountered by projectiles during ordnance velocity perforation of thin aluminum plates were determined for four projectile configurations and three plate thicknesses. The investigation was conducted by holding simulated projectiles stationary and impacting them with aluminum plates. Strain gages bonded to the stationary targets were used to obtain a strain versus time record during perforation; this was subsequently converted into a perforation force record by application of strain wave propagation and linear strain theories. The projectile nose configurations investigated included two cones, a hemisphere and a flat ended cylinder. Peak perforation force and projectile efficiency comparisons were made with results from other investigations.

91 AN INVESTIGATION OF THE CORROSION CHARACTERISTICS OF DENTAL ALLOYS

Terry J. Rickard, Capt, USAF — 91p — GAW/MC/71-11
Advisor: Dr. J. R. Myers — Lab Sponsor: Base Hospital

Cathodic linear polarization behavior of six commercially-available dental alloys was investigated galvanostatically in an aerated synthetic saliva electrolyte, at $22 \pm 1^{o}C$. Each alloy was investigated with three different surface finishes: obtained by grinding with 4/0 emery paper, polishing with dental pumice, and polishing with dental tin-oxide powder. Complete potentiostatic polarization tests were also conducted and anodic Tafel slopes were obtained for these six dental alloys. Due to the effects of concentration polarization, cathodic Tafel slopes were not obtained. Corrosion rate calculations were performed on an IBM 1620 digital computer with a FORTRAN program written specifically for linear-polarization studies. In general, the corrosion rates of all of the dental alloys were very low; ranging from approximately 4 to 200 microns/yr. The gold alloys had the lowest corrosion rates while the amalgams had the highest. All corrosion rates reached steady-state values within 48 to 96 hours. Corrosion rates of each of the alloys decreased as the smoothness of the surface finish increased; the corrosion rates of the amalgams showed the greatest dependence on surface finish.

92 AN INVESTIGATION OF THE EFFECTS OF SQUARE CUTOUTS ON THE NATURAL FREQUENCIES AND MODE SHAPES OF RECTANGULAR PLATES

David C. Gillespie, Capt, USAF | 83p | GAW/MC/71-8
Advisor: Prof P. Nemergut | Lab Sponsor: AFFDL

The effects of square cutouts on the natural frequencies and mode shapes of 7-inch by 10-inch rectangular plates were investigated experimentally by holographic interferometry and theoretically by finite element techniques. It was found that the frequencies of the first mode decreased slightly and then increased as the size of central cutouts increased. The frequencies of the first five modes of plates with 1-inch square cutouts remained constant at various cutout locations. Plates with larger cutouts exhibited larger displacement gradients around the cutouts which may be a measure of the stress concentration around the cutouts.

93 NONSEPARABLE SOLUTIONS OF THE HELMHOLTZ WAVE EQUATION USED IN APPROXIMATING NATURAL FREQUENCIES FOR MEMBRANES OF ARBITRARY SHAPE

Daniel E. E. Hayes, 2nd Lt, USAF | 81p | GAW/MC/71-9
Advisor: Dr. P. J. Torvik | Lab Sponsor: AFFDL | AD 729779

A new method for approximating the natural frequencies of vibrating membranes was developed. The method employs the nonseparable solutions of the Helmholtz wave equation discovered by D. S. Moseley [QAM, Vol. 27, pp. 451–459, 1970] as the elements of a series expansion for membrane displacement. The boundary conditions for a membrane of any shape are then approximated by selecting the coefficients for the expansion so as to minimize the mean square error over a number of points on the boundary greater than or equal to the number of terms in the series representation. This procedure leads to an eigenvalue problem, and the minima in the eigenvalues lead to approximations of the natural frequencies. The resulting approximate solution satisfies the differential equation exactly and approximates the boundary condition. One advantage of the new method is that it furnishes approximations to frequencies of higher modes, as well as the first. The method was applied to shapes for which the exact solutions are known; the results showed excellent agreement. Several nodal patterns were plotted using the approximate solutions. The results indicated that the nodal patterns can also be approximated though more terms in the series representation are required for satisfactory nodal patterns than are required for accurate approximate natural frequencies.

94 AN OPTIMIZATION PROBLEM FOR A VIBRATING BEAM

Joseph A. Crisafulli, 2nd Lt, USAF | 36p | GAW/MC/71-5
Advisor: Major F. E. Eastep | Lab Sponsor AFFDL

The mass distribution of a clamped-clamped beam of square cross section is optimized to produce the maximum first natural frequency. An action integral is constrained with a mass integral creating an isoperimetric formulation. Variations are taken with respect to displacement and beam cross sectional area. The resulting differential equations are solved via Galerkin's technique applied to both the displacement and area functions. The algorithm described satisfies the constraint and area variation equations for each step of the iterative process. Negative values of the Lagrange multiplier were found to indicate an increase in frequency. The beam was constrained to have a minimum area value of 25% of the uniform beam used for comparison. The assumptions made allowed only continuously differentiable area shapes to be generated. The optimum frequency found represented an increase of 38% over the frequency of the uniform beam.

95 A SUBSONIC WIND TUNNEL INVESTIGATION OF AN 8% SCALE MODEL RE–ENTRY VEHICLE WITH LANDING GEAR AND A GROUNDBOARD

Calvin Brown, 1st Lt, USAF | 69p | GAW/MC/71-4
Advisor: Dr. H. C. Larsen | Lab Sponsor: AFFDL

A wind tunnel investigation was performed on an 8% scale model of a re-entry vehicle in different landing configurations. It was desired to determine incremental effects of opening and closing the landing gear housing doors and deployment of the landing gear on the longitudinal performance of the vehicle. In some of the test runs, ground effects were simulated with the presence of a groundboard in the tunnel test section. It was determined that deployment of the landing gear created between four and five times as much additional drag on the vehicle and was added by opening the doors. The main effects of closing the doors while the landing gear was still deployed were a reduction in the trimmed angle of attack and a slight increase in the stability of the vehicle. The effects of close ground proximity on all landing configurations were an increase in lift and lift-curve slopes at all angles of attack tested and a decrease in induced drag at the higher angles of attack.

96 AN ANALYSIS OF THE GENERATION GAP IN THE ARMY AND THE AIR FORCE OFFICER CORPS

Johnny D. Duckworth, Capt, USAF and Donald F. Pederson, Capt, USAF 251p GSA/SM/71-2
Advisor: Col R. H. McIntire Lab Sponsor: AFIT AD 884795

This research investigates the degree to which a generation gap exists in the Army and the Air Force Officer Corps. A generation gap was defined as a difference in attitudes with regard to how important an issue is and/or what is thought about an issue between War College students (over the age of 30) and officer candidates (under the age of 30). A questionnaire was used to determine attitudes on current domestic and international issues. The results of a comparison of responses between generations exhibited a statistically significant difference of opinion in the area of domestic versus international issues in each service. Therefore, a slight generation gap has resulted with the officer candidates placing more emphasis on solving domestic problems in opposition to their senior counterparts. The key to closing this gap is meaningful communication to further the understanding of each generation's attitudes.

97 APPLICATION OF OPTIMIZATION METHODS IN DETERMINING PAYLOAD ALLOCATIONS FOR A FORCE OF PENETRATING AIRCRAFT

John R. Currey, Jr., Maj, USAF 131p GSA/SM/71-1
Advisor: Major K. E. Brant Lab Sponsor: ASD AD 731198

Allocation of the limited number of weapons spaces on a bomber became a problem when the availability of defensive missiles raised the possibility of a trade off between bomber survivability and bomber kill potential in the strategic attack force. This study approaches the allocation problem by partitioning the enemy strategic heartland into discrete areas of constant defensive strength. A Monte Carlo simulation of the air battle between opposing offensive and defensive forces is used to determine the expected number of surviving bombers in each partition. With other factors held constant, the expected number of surviving bombers will be dependent on the quantity of defensive weapons available to them. This expected number of surviving bombers is used to generate a probability of bomber survival in each partition, for each possible load configuration of defensive weapons. Given the relative value of the targets available in each partition, a dynamic programming technique is utilized to enumerate all feasible weapon load configurations and to evaluate, using the associated probabilities of bomber survival, the expected return in target destruction generated by assignment of offensive weapons to those targets. The optimal allocation of weapons spaces is determined for simulated input data and the last chapter provides examples of other types of trade off analyses to which the model may be applied. Additional inferences are drawn with respect to the strategic doctrine which might call for this method of attack.

98 A LOGISTIC QUANTAL RESPONSE MODEL FOR ESTIMATING THE PROBABILITY OF GRADUATE SUCCESS

Thomas A. Pickens, Capt, USAF 75p GSA/SM/71-7
Advisor: Capt R. A. Agnew Lab Sponsor: AFIT AD 725057

The primary method for estimating the correlation between GRE Aptitude Test scores and the probability of graduate success involves calculation of the sample correlation coefficient, but this approach seems to be of little value for prediction or policy formulation. As an alternative, the logistic quantal response model provides a means for estimating the functional relationship between the probability of achieving the graduate degree and the GRE Aptitude Test scores. Data from the Air Force Institute of Technology Graduate Systems Analysis, Graduate Aeroanutical-Mechanical Engineering, and Graduate Logistics management programs were used as the basis for estimating the probability of achieving the graduate degree and nominal 95% confidence bounds for this probability.

99 OUTPATIENT SCHEDULING--A SIMULATION APPROACH

Ronald K. Hall, Capt, USAF 123p GSA/SM/71-3
Advisor: Major R. J. Quayle Lab Sponsor: AMRL AD 884796

Obstetric outpatients, attending the prenatal clinic at the Wright-Patterson AFB Medical Center, were frequently required to wait in excess of one hour to see a doctor even though their consultations were scheduled by appointments. Two causes that contribute to this waiting time are the uncertainty as to the number of doctors that will be available for the clinic and the attempt to eliminate doctor idle time. A computer simulation model was developed to enable experimentation with twelve different appointment systems. The simulation model taken into account four random occurrences (patient arrival time, consultation time, arrival of walk-in patients and number of doctors available) which characterize this particular clinic. The appointment system, recommended for immediate implementation, schedules 10 patients for the first appointment and 5 patients each 10 min. interval thereafter. This recommendation is based on a normally distributed patient arrival time, about a mean of 11.14 mins. before the appointment time, a

gamma distributed consultation time and a mean of 6.86 mins., a 40 min. mean inter-arrival time for walk-in patients and from one to six doctors available. The resulting average patient waiting time and average doctor idle time was 17.73 mins. and 2.82 mins. respectively.

100 A REVIEW OF SOME POPULATION GROWTH MODELS

Rex L. Klaurens, Capt, USAF | 70p | GSA/SM/71-4
Advisor: Capt R. A. Agnew | Lab Sponsor: AFIT | AD 884797

This paper reviews some of the past and present models used in forecasting human population levels. The models have been divided into two groups – deterministic and stochastic. The deterministic area mentions the exponential law of growth, the logistic law, stable population theory, matrix models and methods of the U.S. Census Bureau. The stochastic portion is limited to continuous time, discrete state Markov processes with the linear birth, linear birth and death, linear birth and death with immigration, and an analog to the logistic process being reviewed. An attempt was made to project the population of the United States with the linear birth and death process in order to obtain percentile limits on the projection. The range between the upper and lower limits on such projections was found to be unreasonably narrow. It was concluded that the restrictive assumptions of such a model prevented a more realistic approximation. The paper contains recommendations for further research and a large bibliography.

101 A REVIEW OF SOME STOCHASTIC MODELS OF BIOLOGICAL INTERACTIONS

Charles K. Staley, Capt, USAF | 53p | GSA/SM/71-12
Advisor: Capt R. A. Agnew | Lab Sponsor: AMRL

Models of biological interaction were first developed by Lotka and Volterra, around 1925. These early models were deterministically formulated, and hence, drew the complaint that they did not take account of nature's random aspects. In 1939, Feller was among the first to develop population growth and interaction models using stochastic processes. Though the formulation of such models is fairly easy, the mathematical intractabilities usually encountered can prevent explicit solutions from being demonstrated. Chiang provides the general model used in this report for species' interaction. Models involving competition for a common food supply and the prey-predator relationship are investigated. Due to the difficulties in obtaining explicit solutions, alternate approaches to solution, e.g., simplification, approximation, and Monte Carlo simulation are discussed. As an example of how stochastic models can be used, Park's experimental results on the interaction of two species of Tribolium are reviewed along with two models proposed by Neyman, Park and Scott and Leslie, and a Monte Carlo approach.

102 SOME APPLICATIONS OF STOCHASTIC OPTIMAL LINEAR ESTIMATION THEORY

Dennis L. Schultz, Capt, USAF | 55p | GSA/MA/71-3
Advisor: Dr. D. R. Barr | Lab Sponsor: SAMSO

In 1963, J. A. Bather published a model on the performance level of a machine and derived an estimate of the current performance level using probability density functions. In 1970, A. Albert published a model on stock market prices and an estimate of the current drift of the market. Abstractly, Bather's and Albert's models are the same and are special cases of a very general stochastic discrete linear model from a body of theory known as estimation theory. Similarly, Bather's estimate of the current performance level of a machine and Albert's estimate of the current drift of the stock market are abstractly the same and can be derived in an alternate manner by using the technique of stochastic optimal linear estimation. In the terminology of the general stochastic discrete linear model, Bather's performance level and Albert's drift would be called the "state of nature" for their respective models. Predicted estimates of the state of nature at some future time as well as estimates of what the state of nature was at some time in the past are also computed using the techniques of stochastic optimal linear estimation. The formulation of Albert's model allows us to write his model in a form which can be used to compute the conditional and unconditional mean and variance of the price of the stock and drift in a simple manner. Albert's model is invariant, i.e. the form remains the same, under changes in starting time and under changes in the time units; however, different parts of the model are altered in different ways when the time units are changed. Albert's model is also invariant when linear combinations of prices are used.

103 A SUPPLEMENT TO HAIGHT'S "INDEX TO THE DISTRIBUTIONS OF MATHEMATICAL STATISTICS" WITH A DISCUSSION OF THE EXCEEDANCE DISTRIBUTION AND SOME RELATED DISTRIBUTIONS

Joseph L. Rhodes, Jr., Capt, USAF — 94p — GSA/MA/71-1
Advisor: Dr. D. R. Barr — Lab Sponsor: ARL

To help eliminate unnecessary derivation of results already in the literature, a supplement to Frank A. Haight's "Index to the Distributions of Mathematical Statistics" (Ref 17) is presented. It is a partial update, covering articles from the Journal of the American Statistical Association, January 1958 to December 1967. The index's usefulness to the researcher is illustrated by the researching of three related distributions (exceedance, negative hypergeometric, and inverse hypergeometric) using the reference given in Haight's Index as a starting point. As the result of this research, a bivariate exceedance distribution and an alternate method of obtaining an exact confidence interval for the difference of the medians of two populations whose distribution differs only in location are derived.

104 TABLES FOR UNBIASED TEST OF VARIANCES WHEN SAMPLING FROM NORMAL DISTRIBUTIONS

Joachim E. Scholz, Maj, USAF — 74p — GSA/MA/71-2
Advisor: Dr. D. R. Barr — Lab Sponsor: ASD

A two sided test for the equality of variances of two random samples, each from a normal distribution, is given. The test is completely unbiased and is of minimum logarithmic length. Tables for the unbiased test for alpha-levels .1, .05, and .01 and instructions for their use are included. Unbiased confidence intervals may also be constructed from these tables.

105 A THEORETICAL STUDY OF INDEX NUMBER CONSTRUCTION FOR DOD USE

Richard A. Spencer, Capt, USAF — 171p — GSA/SM/71-11
Advisor: Dr. H. Enzer — Lab Sponsor: AFIT — AD 885014

The statistical and economic theory of price index numbers as developed from 1920 to 1970 is presented. Using theoretical and practical considerations, criteria are established for a military price index. Sixteen price index formulas are then evaluated and ranked in order to preference according as they exhibit appropriate properties. Two prediction models for use with index numbers are then developed and evaluated.

106 A COMPARISON OF SPAN LOAD DISTRIBUTION CALCULATION METHODS FOR SWEPT WINGS

Merwin E. Spragg, Capt, USAF — 75p — GAM/AE/71-3
Advisor: Capt S. J. Koob — Lab Sponsor: AFFDL — AD 883700

The study compares several lifting theories for thin wings in subsonic flow with available experimental data and indicates the best method for predicting span load distributions and lift-curve slopes. The Schrenk, Lifting Line, Weissinger, Falkner, and Kernel Function methods are compared with each other, with wind tunnel data available in the literature, and with flight test data for all the Air Force's C-5A aircraft. It is concluded that the Falkner vortex lattice method is the best overall.

107 CONTROL OF THE AMPLITUDE OF DEFLECTION OF A SIMPLY SUPPORTED PLATE THROUGH THE ADDITION OF CONSTRAINED VISCOELASTIC LAYERS

Daniel Z. Strickland, Jr., Capt, USAF — 75p — GAM/MC/71-4
Advisor: Dr. P. J. Torvik — Lab Sponsor: AFFDL

Viscoelastic materials are used extensively to damp flexual vibrations of metallic structures; it has been known for some time that energy dissipation due to shear strain in the viscoelastic layer can be increased by constraining it with a stiffer covering layer. For this report two configurational additions employing multiple anchored viscoelastic layers and one employing multiple unanchored layers were designed and applied to simply supported plates. The energy dissipated in both free and forced vibrations was determined experimentally for all configurations. The damping in forced vibrations was determined from the response curve near the resonant frequency. The damping in free vibration was determined by driving the plate at resonance, disconnecting the driving mechanism, and measuring the decay. For all configurations, the logarithmic decrement was essentially independent of the amplitude, and three to five times the decrement for an untreated plate. The unanchored damping addition is a two-dimensional version of the configuration described, analyzed, and tested by Plunkett and Lee (J.A.S.A. Vol. 48, pp. 150–161, 1970). The experimental results for an optimum structure were within 10% of the predictions of analytical evaluation. Limited data at the resonant frequency of a higher mode indicate this addition retains its effectiveness.

108 DYNAMIC ANALYSIS AND SIMULATION OF HYDRAULIC CONTROL SYSTEMS

Santo C. Maggio, Civ | 125p | GAM/ME/71-6
Advisor: Dr. M. E. Franke | Lab Sponsor: ASD

Using a simplified system model consisting of a pump, transmission line, and load valve, a general procedure is devised for analyzing the dynamic performance of a hydraulic control system. Mathematical models are developed for each component in terms of the pressures and flows into and out of the component. The individual models are combined into a complete system model which is used to simulate system operation on a hybrid computer. Simulation of pump operation without the transmission line attached is also performed on hybrid and digital computers. Results of the system simulations are shown to agree qualitatively with simple wave theory. Pump simulations on the hybrid and digital computers correlate very well, and the digital results compare favorably with the steady-state performance curve of a typical pump. The transmission line model is validated by comparing the results of waterhammer simulations with those of another author who recently developed the model. This model accounts for the unsteady fluid frictional effects of attenuation and dispersion, yet it is simple to use for transient response analysis. This approach to dynamic system analysis can be expanded to more complex systems. It is a model that can be used to predict the dynamic performance of fluid power systems in the design stage.

109 EFFECT OF INLET CONTOUR ON THE INTERACTION OF A SHOCK WITH A REDUCED SECTION IN A SHOCK TUBE

Raymond H. Rhode, Jr., Capt, USAF | 62p | GAM/ME/71-7
Advisor: Dr. A. J. Shine | Lab Sponsor: AFPL | AD 882077

The effect of a rounded inlet contour on the interaction of a shock wave with a change in cross-sectional area was investigated using an air-air shock tube. An abrupt reduction was used as a base for comparison. The incident shock Mach numbers ranged from 1.37 to 1.63. The rounded inlets produced larger increases in transmitted shock velocity than the abrupt reduction. Schlieren photographs taken at the entrance to the reduced section show that this increase is due to the formation of stronger transverse waves which interact with and thereby strengthen the transmitted wave.

110 THE EFFECT OF NOZZLE WALL CONTOUR ON THE PERFORMANCE OF A TWO-DIMENSIONAL SUPERSONIC BISTABLE AMPLIFIER

Warren S. Bollmeier II, 1st Lt, USAF | 75p | GAM/ME/71-1
Advisor: Dr. M. E. Franke | Lab Sponsor: AFPL | AD 883246

An experimental investigation of the effect of nozzle wall contour on the performance of a two-dimensional supersonic bistable amplifier was performed. The addition of ribbed and curved wall sections to a basic straight wall design in the region between the nozzle throat and the control ports was considered. The performance parameters considered were the supply pressures, total pressures distributed in the output leg, and the switching times. When compared to the straight wall design, the results from the curved wall tests indicated improved total output pressure distributions and faster switching times with a loss in flow stability. The results from the ribbed wall test indicated improved total pressure distributions and slower switching times with greater flow stability.

111 THE EFFECT OF PROJECTILE STRENGTH ON CRATER FORMATION

Nicholas C. Byrnside, Capt, USAF | 102p | GAM/MC/71-2
Advisor: Dr. P. J. Torvik | Lab Sponsor: AFML

The effect of projectile strength on cratering was investigated for projectiles of four aluminum alloys impacting semi-infinite aluminum targets over the velocity range of 1 km/sec to 5.0 km/sec. Final crater dimensions and peak shock pressure were selected as parameters for comparing projectile strength effects. The experimental results showed that crater diameters were not significantly influenced by varying projectile strength. The crater depths were found to vary significantly with strength at lower velocities but to become virtually the same at 3.5 km/sec for the projectile alloy series investigated. Peak shock pressure experimental results were inconclusive due to the large scatter in the experimental data. A simple dynamic model for cratering was developed and compared with experimental results of this study and some AFML hypervelocity experimental results. These comparisons showed that the coupled model provided predictions of crater diameter which were within 8% for the experimental results of this study and within 13% for the hypervelocity data. Crater depth predictions were consistently less than the experimental results of this study and were within 13% for the hypervelocity data. The predictions of depth and diameter as a function of velocity showed qualitative agreement with the experimental results of this study and the AFML hypervelocity data.

112 THE EFFECT OF SIMULATED ABLATION ON THE LONGITUDINAL STABILITY OF AN 8% SCALE MODEL RE–ENTRY VEHICLE

James H. Manly, Maj, USAF | 82p | GAM/AE/71-2
Advisor: Dr. H. C. Larsen | Lab Sponsor: AFFDL

Wind tunnel tests were conducted to study the effect of simulated ablation on the longitudinal stability of an 8% scale model re-entry vehicle. As suggested in a previous study, commercial emery cloth was used to provide the roughness. When ablated, the model (designated as the FDL–8) pitched up at angles of attack above 16^{o}, whereas without ablation instability was delayed until 21^{o}. It is known that when breakdown of leading-edge vortices occurs over a wing, there is a certain loss of lift, drag, and nose-down pitching moment. Using the tuft grid photograph technique and the total head survey technique, it was shown that the presence of the simulated ablation causes premature breakdown of lifting vortices found above the model and thus early onset of instability.

113 EXPERIMENTAL STUDY OF A LAMINAR BOUNDARY LAYER ON A BODY OF REVOLUTION

George R. Wilson, Maj, USAF | 91p | GAM/AE/71-4
Advisor: Major J. V. Kitowski | Lab Sponsor: ARL

The effects of angle of attack variation on the streamwise velocity profiles, the pressure distribution, and the separation point for a laminar boundary layer on the leeside centerline of an elliptical body of revolution were studied. On the leeside centerline for angles of attack greater than 12^{o} the boundary layer velocity profiles behave in a dissimilar way to those of two dimensional flow and the pressure gradient deviates from the inviscid solution becoming favorable along the aft portion of the body. The separation initially moves forward on the centerline then moves aft for angles of attack greater than 3^{o}.

114 FLUIDIC CAVITY OSCILLATORS

Grinnell Jones III, Capt, USAF | 47p | GAM/ME/71-5
Advisor: Dr. M. E. Franke | Lab Sponsor: AFPL | AD 882872

The effects of cavity diameter and jet-exit distance on the frequency response of jet-driven cylindrical cavity oscillators are determined over a wide range of flow rates. The oscillators have regions of operation in both the fundamental and higher frequency modes analogous to a multi-stage jet-edge resonator. With frequency and flow rate expressed as Strouhal number ($St=f\pi D/a$) and Reynolds number ($re=uD/v$) for several cavity diameters, the experimental results show distinct similarity. The effect of jet-exit distance on the Reynolds number is determined. Schlieren photographs of the fundamental mode show the jet oscillating laterally at the cavity resonant frequency.

115 AN INTERFEROMETER STUDY OF AIR FLOW NEAR THE EXIT OF A CONSTANT AREA DUCT FOLLOWED BY A VARIABLE DIVERGENT SECTION

Raymond L. Harris, Capt, USAF | 46p | GAM/ME/71-4
Advisor: Dr. A. J. Shine | Lab Sponsor: AFPL

Fluid properties of both fully-developed, turbulent flow and undeveloped, laminar flow near the exit of a constant area duct followed by a variable divergent section were investigated and compared. Points of flow separation were also compared. A Mach-Zehnder interferometer was used to obtain density data and flow visualization. The fluid properties of the fully-developed, turbulent flow changed more than the undeveloped, laminar flow at the constant area exit as the divergence angle increased. The two regimes of flow appeared to be identical through the divergent section.

116 INVESTIGATION OF A VORTEX IN THE INLET OF A SUBMERGED NOZZLE

David W. Fleeger, Capt, USAF | 86p | GAM/ME/71-3
Advisor: Dr. A. J. Shine | Lab Sponsor: AFPL | AD 884156

A cold flow study was made of a vortex in the cavities of both two-dimensional and axisymmetric submerged nozzles. In the two-dimensional nozzle the cavity configuration was changed by honeycomb, fillets, and width and depth reduction blocks. Vortex meters were used to measure relative vortex strength. Pressure measurements were made in and near the cavity. Boundary layers were bled. Results revealed that honeycomb decreased vortex formation, while fillets increased it. Cavity width reduction increased frequency of appearances. High and low amplitude pressure fluctuations were observed. End wall boundary layer bleed did not eliminate the vortex. Flow characteristics were noted.

117 AN INVESTIGATION OF THE EFFECT OF TEMPERATURE ON THE COANDA INTERACTION BETWEEN A JET AND A CURVED PLATE

Joseph M. Campbell, Jr., Capt, USAF | 101p | GAM/ME/71-2
Advisor: Dr. A. J. Shine | Lab Sponsor: AFFDL | AD 883802

A rectangular nozzle with a variable nozzle width exhausted gas over a curved plate of constant radius. The gas (combustion products of JP–4 and air) was at temperatures varying from ambient to 1700 R and a stagnation pressure of from 15.0 to 30.0 in Hg. A turning efficiency was evaluated from the measurements of deflected to undeflected thrust. The paper includes pressure distributions over the curved plate, schieren patterns, and total pressure profiles across the flow exit plane. It was found that the turning efficiency is reduced by decreasing stagnation pressure, increasing stagnation temperature and decreasing nozzle width.

118 AN INVESTIGATION OF THE USE OF SPIN–STABILIZED CUBES AS FRAGMENT SIMULATORS IN ARMOR EVALUATION

Randall L. Schamberger, Capt, USAF | 90p | GAM/MC/71-8
Advisor: Major W. Goldberg | Lab Sponsor: AFML

An investigation was made of the use of cubes as fragment-simulators for armor evaluation and testing. One-quarter inch steel cubes were launched from a rifled barrel to induce stability through spin stabilization. Specially molded lexan sabots were used to launch the cubes in the three predominant orientations: flat, edge, and point. The success rate of impact orientation predictability was high enough to warrant further consideration of cubes as fragment simulators. V_{50} ballistic limits were determined for four armor materials under flat, edge, and point impacts. The ballistic limits determined with cubes differed considerably from those determined with standard fragment-simulating projectiles at the same mass. Metallic armor materials failed at higher velocities for the cubes, while fibrous armor materials were penetrated at lower velocities by the cubes. An alternate method for determining ballistic limits with cubes is also presented. Drag coefficients were determined for the three predominant orientations over the range of Mach number 0.5 to 3.5 and found to be generally higher than those previously measured by investigators who assumed cubes tumbled in flight.

119 NATURAL FREQUENCIES AND MODE SHAPES OF PLATES WITH INTERIOR CUT–OUTS

Jon Monahan, 2nd Lt, USAF | 90p | GAM/MC/71-1
Advisor: Dr. P. J. Nemergut | Lab Sponsor: AFFDL

The effect of square holes on the natural frequencies and mode shapes of a 7 in X 10 in clamped rectangular plate were investigated. The frequencies of the first five modes were obtained in separate experiments using holographic interferometry and accelerometers and analytically using the finite element method. The shapes were observed in the holography experiment and photographs were taken. For a plate without holes, the experimental frequencies were approximately 10% lower than the theoretical values possible due to some rotation of the plate edges. Using a 25 element model, the finite element program gave frequencies within 1% of the theoretical values. For central square holes, the frequencies of each mode varied with hole size in a number of ways. A correlation between the variation of frequencies and mode shapes was noted. As compared to the mode shapes of a solid plate, it was found that for holes equal to or less than two inches, the mode shapes were only slightly distorted. The larger holes resulted in an interchanging of the mode shapes of the fourth and fifth modes and considerable distortion of several of the mode shapes. The frequencies predicted by the finite element program were accurate for the plates with holes less than three inches.

120 PREDICTION OF FLOW ANGULARITY NEAR A SUPERSONIC FUSELAGE FOREBODY WITH ARBITRARY CROSS–SECTION

Jerome A. Forner, Civ | 56p | GAM/AE/71-1
Advisor: Capt S. J. Koob | Lab Sponsor: AFFDL | AD 882870

A simple method was developed to predict flow angularity around the side of a typical uncambered fuselage forebody at supersonic speeds with zero sideslip. The method falls within the class of slender body solutions in small perturbation theory. The body cross-section at any axial location is analytically described by an infinite cosine series, whose coefficients vary with axial position as the body cross-section changes. A disturbance velocity potential is found, which is made up of axial and crossflow components due to an equivalent body of revolution, plus axial and crossflow components which adjust for the body asymmetry. The potential is made to satisfy the approximate boundary conditions of flow tangency on the body. A computer solution provides CALCOMP plots which compare the theoretical crossflow around a fuselage forebody for which experimental data was available. Comparisons were made at Mach 2.5 with angles of attack of -7.5, 7.5 and 12.5 degrees and Mach 2.2 at 8.3 degrees.

Agreement of flow angularity is generally good. Surface static pressures were also compared at Mach 2.2 and agreement was unsatisfactory. Recommendations for possible improvements to the method are made.

121 RESPONSE OF VISCOELASTIC MATERIALS TO RANDOM LOADING

Michael L. Valentine, 2nd Lt, USAF — 72p — GAM/MC/71-3
Advisor: Major W. Goldberg — Lab Sponsor: AFML

In this study a method was developed to simulate the random loading history that a structure experiences in service. This method produces a random load that duplicates the irregularity factor, the power spectral density, and the load spectrum of the service load. An experimental investigation was conducted to determine the response of viscoelastic materials to random loading histories. The random loading histories were generated by the method mentioned above. Experiments were conducted on two different materials. One specimen was made of quasi-isotropic fiberglass epoxy composite material, and the other was an SBR rubber cylinder. The dynamic compliance for each material was determined by viscoelastic interconversion of data from creep tests. Two random vibration experiments at different irregularity factors were conducted on each specimen. The experimental results were compared to results predicted from random vibration theory and linear viscoelasticity. The experimental results for both specimens were in very good agreement with the predicted results.

122 SOME NECESSARY CONDITIONS FOR TIME–OPTIONAL FIXED–FUEL TRANSFERS BETWEEN COPLANAR ORBITS

Ronald C. Tubbs, Capt, USAF — 60p — GAM/MC/71-6
Advisor: Major G. M. Anderson — Lab Sponsor: AFIT

Some necessary conditions in terms of the state and costate variables are derived for time-optimal, thrust-coast-thrust (TCT) trajectories between coplanar, cofocal orbits in an inverse-square gravitational field. Assuming impulsive thrusting, the transfer trajectories are determined by solving a quartic polynomial in the square root of the semi-latus rectum of the transfer orbit. The IBM 7094 digital computer was programmed to solve the polynomial and isolate the root leading to the optimal trajectory. Final mass to initial mass ratios are specified, and initial mass is taken as unity. The necessary conditions are derived using plots of constant mass contours in the transfer angle vs transfer time plane. The conditions are intended to indicate when the TCT trajectory is not optimal and should be replaced by another type of trajectory, such as coast-thrust-coast-thrust (CTCT) or thrust-coast-thrust-coast (TCTC). Transfers between both circular and elliptic orbits are investigated. Results indicate that regions exist where the TCT trajectories are not optimal.

123 STRESS CORROSION CRACKING OF HOT–DIP GALVANIZING ALLOY

Gerald R. Foster, LCDR, USCG — 47p — GAM/MC/71-7
Advisor: Dr. J. R. Myers — Lab Sponsor: AFML

Stress corrosion susceptibility of eta-phase, hot-dip galvanizing alloy was evaluated in slightly acidified (pH=5) tap water at 140°F (60°C). Concurrently, general corrosion rates for this alloy were determined utilizing linear polarization and long term weight loss tests in both slightly acidified (pH=5) and normal (pH=7.2) tap water at 140°F (60°C). Additional testing was conducted to determine whether premature cracking failures were due to classical stress corrosion or hydrogen embrittlement. Eta-phase, hot-dip galvanizing alloy was found to be susceptible to stress corrosion failure; cracking morphology was observed to be intergranular. Time to failure decreased with increasing applied tensile stresses; failure occurred after 2850 hours at 2040 psi and 150 hours at 6720 psi. Based upon preliminary cathodic polarization tests of stressed specimens, hydrogen embrittlement is probably not involved in the premature failure mechanism. General corrosion rates predicted from linear polarization data compared favorably with those obtained in the weight-loss tests. At 140°F (60°C), these corrosion rates were approximately, 50μ/yr in normal tap water and 300μ/yr in slightly acidified tap water. These relatively-low general corrosion rates could not sufficiently reduce the cross-sectional area of the stressed specimens and cause failure; similarly, low-temperature creep is not involved in the failure process.

124 TOTAL RADIATION MEASUREMENT FROM BORON LADEN FLAMES

William J. Rothschild, 1st Lt, USAF — 89p — GAM/ME/71-8
Advisor: Dr. J. E. Hitchcock — Lab Sponsor: AFRPL

Radiometers have been fabricated to measure the total intensity of irradiation along the secondary combustion chamber wall of an air-augmented rocket, which burned solid propellants containing high boron concentrations. The radiometers consist of "Gardon" or "thin-foil" calorimeters in housings which are cooled and purged by gaseous nitrogen. The design analysis of these radiometers, for this application, is presented.

Measured intensity of irradiation profiles show a maximum at the forward end of the secondary combustion chamber for various propellants and test conditions. Intensity of irradiation declines rapidly as air/fuel ratio increases from 10 to 30. There is good correlation between combustion efficiency and radiometer outputs.

125 A STUDY OF THE JOB ATTITUDES OF BLUE–COLLAR WORKERS IN THE CIVIL SERVICE ENVIRONMENT

Richard J. Biggs, LtCol, USAF | 63p | GSM/SM/71-1
Advisor: Lt Col R. J. Lucas | Lab Sponsor: AFLC | AD 732910

This research is designed to measure the job attitudes of the wageboard employees within the Aircraft and Engine Division, Directorate of Maintenance, Sacramento Air Material Area, California. Development of this research is based on an attempt to test the Herzberg Two-Factor Theory of Motivation on the blue-collar worker in the civil service environment. Data is obtained from fifty-nine subjects, reduced and analyzed using the Herzberg methodology. Three basic conclusions are drawn from the results of this research: (1) The wage-board employee is motivated by much the same hierarchy of facotrs as are employees in the industrial setting. (2) There is some evidence that parameters in the civil service environment have intensified the pre-potency of Working Conditions and Advancement as dissatisfiers, thus modifying the hierarchy of factors which result in job dissatisfaction for the wage-board employee. (3) Salary, as a monetary reward, is apparently of no significance in determing the job attitudes for the wage-board subjects of this research.

126 A COST/DECISION MODEL FOR THE DEFERRED PROCUREMENT OF AN AIR FORCE DEPOT MAINTENANCE CAPABILITY–WITH A COMPUTERIZED APPLICATION TO THE F–15 INS

Michael S. Clark, Capt, USAF and Robert E. Johnson, Capt, USAF | 240p | GSM/SM/71-2
Advisor: LtCol C. J. Doryland | Lab Sponsor: ASD | AD 735351

This study presents a decision model to aid decision-makers in evaluating the costs of establishing an Air Force depot maintenance capability at different points in time. The cost elements of depot maintenance are identified and defined in denotative terms. The model incorporates techniques for the explicit treatment of uncertainty, converting dollar requirements into expenditures, and the considerations of inflation and discounting (present value). The model is computerized in BASIC computer language and its utility demonstrated by applying it to an actual depot maintenance phase-in problem – the F–15 Inertial Navigation System (INS).

127 A FORCE SURVIVAL MODEL FOR ANALYSIS OF STRATEGIC BOMBER BASING CONCEPTS IN THE PRELAUNCH SURVIVAL MODE

Douglas D. Cochard, Capt, USAF and Robert E. Riggs, Capt, USAF | 136p | GSM/SM/71-3
Advisor: Major K. Brant | Lab Sponsor: ASD | AD 732193

The prelaunch survival of strategic bombers will continue to be an important problem as long as they are to remain a viable part of the deterrent triad for the United States. Improving enemy technology and changing enemy strategies call for continued analysis of the problem. This study examines the parameters which govern prelaunch survival of strategic bombers. A model is developed to allow computation of total bomber force survival given the values for the necessary parameters. Several basing concepts and other means of improving force survival are analyzed with the aid of the model. Cost effectiveness analysis of the concepts discussed should be accomplished, and the results compared to other possible means of improving survival, e.g., ABM systems, before conclusions are made from the results of this study.

128 A STUDY OF ENVIRONMENTAL FACTORS INFLUENCING PERCEIVED CAREER PROGRESSION OF CIVIL SERVICE EMPLOYEES

Donald A. Dunham, Capt, USAF | 170p | GSM/SM/71-4
Advisor: LtCol R. J. Lucas | Lab Sponsor: AFLC | AD 733377

This research concerned the measurement of Civil Service employee's perceptions of the factors related to career progression and the identification of the factors of their job environment which influenced these perceptions. The research sample was taken from a population of General Schedule (GS) personnel in the grades 9–15 in the Directorate of Materiel Management of an Air Material Area of the Air Force Logistics Command. The measurement of career progression perceptions consisted of measuring employee perceptions of the content of five key factors in their jobs. These factors, which Hersberg identified as motivators, are: achievement, recognition, job interest, responsibility, and advancement. Two hundred and twenty Civil Service employees answered questionnaires furnishing the above measurements as well

as ratings of their feelings of job security, career motivations and expectations, and the importance of the motivators with respect to their career progression. This data was analyzed to identify significant differences between employees grouped according to various characteristics and to identify significant relationships between several charactersitics and overall perceptions of career progression and the importance weights for the motivators. In addition, a sub-sample of 29 employees was interviewed to obtain additional information regarding the reasons for responding to the questionnaire in the manner reported. Summaries of the interviews revealed frequently mentioned conditions of the job environment which reportedly tended to prevent or fester high perceptions of the motivators.

129 A COMPARATIVE ANALYSIS OF PERCEIVED SOURCES OF AUTHORITY OF FUNCTIONAL VERSUS PROJECT MANAGERS IN THE AIR FORCE LOGISTICS MANAGEMENT ENVIRONMENT

Herbert H. Edwards, Maj, USAF | 138p | GSM/SM/71-5
Advisor: Dr. R. H. Klug | Lab Sponsor: AFLC | AD 733378

This research examines the perceptions of authority of functional and project managers in the Air Force Logistics Management environment. Questionnaire/interview sessions were conducted within the Directorate of Materiel Management, Sacramento Air Materiel Area, California, to measure and compare the perceptions of project and functional managers regarding sources of authority, authority styles and existent authority gaps. Five classifications of sources of authority and three authority styles were classified for a comparative analysis. The sources of authority were expert, formal, punishment, referent and reward authority; the three authority styles were the autocratic, utilitarian and supportive. Project and functional managers were asked to rate their most important and most frequently used source of authority, to estimate the amount of authority they possessed in their jobs and the amount of authority they wanted and to rate their most important and most frequently used authority style for routine and high priority situations. The analysis of the responses revealed that no significant differences existed in the perceptions of authority of project and functional managers. Project and functional managers perceived their sources of authority to be the same with referent,formal, and expert authority being the main sources of authority. Project and functional managers perceived similar reward and punishment authority gaps and predominantly used the supportive authority style for both routine and high priority requests irregardless of their primary source of authority.

130 ANALYSIS OF THE FACTORS GOVERNING THE SCHEDULING OF FLIGHT CONTROLLERS IN SUPPORT OF LONG DURATION MANNED SPACEFLIGHT MISSIONS

Carroll E. Hopkins, Capt, USAF | 182p | GSM/SM/71-6
Advisor: Major R. J. Quayle | Lab Sponsor: AFIT | AD 731765

This study has two main purposes: to identify the factors, or variables, that govern the scheduling of flight controllers in support of long duration manned spaceflight; and to develop a scheduling system that best satisfies the needs of these personnel and the activity they support. A review of related research yielded a tentative list of nine scheduling variables. They are: fatigue, flexibility of schedules, length of shift, morale, office work, overtime, personnel qualifications, shift cycle, and training. A questionnaire was developed to verify these variables, to measure the relative importance of them, and to determine which of five proposed schedules were perceived by the flight controllers as being the best. Hypotheses were tested to determine if the flight controllers and their supervisors perceive the importance of these scheduling variables differently. Other organizations performing similar tasks were studied to provide a data base of scheduling systems in use. The verification process resulted in acceptance of all variables. The tests of the hypotheses revealed that little differences exist in the importance of scheduling factors as perceived by the groups tested. A schedule is proposed by the author that will provide the best mission support. This schedule was arrived at independently yet is similar to that schedule most desired by the flight controllers.

131 FAMILY FINANCIAL PROTECTION FOR A RETIRING MEMBER OF A UNIFORMED SERVICE

Morris C. Johnson, Capt, USAF | 127p | GSM/SM/71-7
Advisor: Maj R. J. Quayle | Lab Sponsor: AFIT | AD 734747

This thesis develops a systematic method to aid a retiring member of a uniformed service in the decision making required to provide family financial protection in case of his death. The method presented aids in the selection and preference ranking ofooptions of the Retired Serviceman's Family Protection Plan and/or other commercial life insurance methods. Present value criteria and methods are discussed and used in comparison calculations of the various protection methods available to the serviceman. The thesis findings of the preference order of obtaining financial protection methods are the result of many case comparisons. The majority of comparisons indicated that Option Two

of RSFPP is the least cost method of providing for a temporary protection need and commercial term insurance ranks second. The least cost preference order indicated for a permanent financial protection need is Option One or Three of RSFPP, whole life insurance, and limited-payment life insurance. The methodology of finding a preference order, including a cost/benefit ranking computer program, is provided so an individual can use personal family factors such as his age, wife's age, number of children, etc. A protection plan computer program is provided to outline a dollar value insurance plan that guarantees that the serviceman's family financial protection objectives will be accomplished. The presented plan demonstrates the impact of the time value of money and the usefullness of the Retired Serviceman's Family Protection Plan.

132 AN EXAMINATION OF RECENT DEFENSE CONTRACT OUTCOMES IN THE INCENTIVE ENVIRONMENT

John M. Parker, Jr., Capt, USAF | 84p | GSM/SM/71-9
Advisor: Lt Col D. L. Belden | Lab Sponsor: ASD | AD 731764

This thesis presents an empirical evaluation of the outcomes of a large number of recently completed defense contracts. Profit outcomes and cost growth resulting from changes in the scope of the contract and from overrun/underrun are examined for incentive and fixed fee contracts. Incentive features such as share ratios and multiple incentives are investigated to determine their effect on contract outcomes. Linear regression and analysis of variance techniques are used to analyze the outcomes of 2683 Army, Navy, and Air Force contracts. The types of contracts included in the data sample are fixed-price, incentive, cost-plus-incentive-fee, and cost-plus-a-fixed-fee contracts. No meaningful relationship is found to exist between cost overrun/underrun and changes in the scope of the contracts analyzed. The contract change percentage is found to decrease as the contractor's portion of the share ratio increases. Also, incentive contracts with large contractor share rates are found to have a tendency to overrun. An examination of multiple incentive contracts reveals that contracts with performance incentives, as well as cost incentives, tend to earn performance incentives, regardless of the contract cost outcome.

133 AN EXPLORATORY STUDY ON A BEHAVIORAL APPROACH TO POSITION DESCRIPTIONS IN A GOVERNMENT SETTING

Richard C. Parker, Capt, USAF | 51p | GSM/SM/71-10
Advisor: LtCol R. J. Lucas | Lab Sponsor: ASD | AD 736205

This study was an initial exploratory attempt to applying concepts from the behavioral sciences and organizational dynamics to the problem of describing positions in a Government project setting. A behavioral position description model was developed, based on role theory. In the model, the position was viewed as the focal point of a role set. Its nature was influenced by various organizational, personal and interpersonal facotrs. Eleven of these factors were identified as tentative behavioral descriptors from literature on behavioral sciences and project management. Interviews with ten Government civil service employees in the project environment at the Air Force Aeronautical Systems Division, Wright-Patterson AFB, Ohio, suggested that nine of the eleven descriptors were relevant to positions in a project setting. It was concluded that a behavioral approach to position descriptions in a Government project setting is viable. There are practical limitations to the behavioral position description model, but its use as a conceptual basis for describing positions has merit.

134 A CONCEPTUAL MODEL FO THE APPLICATION OF THE SYSTEMS APPROACH TO ORGANIZATIONAL THEORY IN A USING COMMAND HEADQUARTERS

Stephen A. Soltesz, Maj, USAF | 154p | GSM/SM/71-11
Advisor: Lt Col C. J. Doryland | Lab Sponsor: AFIT

An exploratory study of private and public management literature revealed six system organizational characteristics. These characteristics were structured into a conceptual organizational model to provide for the management of system activities associated with all four phases of a weapon/airlift system's life cycle. A field study of four Air Force Using Commands, Aerospace Defense Command, Military Airlift Command, Strategic Air Command, and Tactical Air Command, provided a description of the functional and system organizations of each. These four operational models were compared with the conceptual model. A comparative analysis revealed that structuring a system organization with all of the characteristics used in the conceptual model was feasible. However, the useability of all six of these characteristics was not considered as highly probable, since three out of four operational models did not employ all of them. It was concluded that a useable model would have to be structured to provide for the management of system activities only through the first two phases of

a system's life cycle. Further, the tenure of the system organization would span only these firt first two phases.

135 AN ANALYSIS OF DOD/NASA CONTRACTOR PROFITABILITY IN THE INCENTIVE CONTRACT ENVIRONMENT

Jerry E. Trimble, Capt, USAF | 100p | GSM/SM/71-12
Advisor: Lt Col D. L. Belden | Lab Sponsor: AFSC | AD 732909

This research evaluates the results of the increased use of incentive-type contracts by the Department of Defense and the National Aeronautics and Space Administration. The efficiency and productivity resulting from the use of capital and labor resources by the defense and space firms are compared over a period of time with a group of similar firms having purely commercial business. The comparison is made with the following financial indicators: returns on sales, equity capital and total assets, equity capital turnover, total assets turnover, and sales dollars per employee. This analysis shows that the intensified incentive environment has failed to induce defense and NASA contractors toward increased efficiency and productivity in the use of capital and labor resources. These firms as a group are less profitable and show a less favorable financial status than purely commercial firms.

136 AN INVESTIGATION OF GOVERNMENT EMPLOYEE PERCEPTIONS OF THEIR ORGANIZATIONAL CLIMATE

Robert K. Wagner, Maj, USAF | 142p | GSM/SM/71-13
Advisor: LtCol R. J. Lucas | Lab Sponsor: ASD,AFLC | AD 735352

This research was devoted to the investigation of perceptions of organizational climate among government employees. The research was conducted within three functional directorates of an Air Materiel Area of the Air Force Logistics Command. The sample population consisted of civil service employees in grades GS-9 through GS-16 and military officers of the ranks of Major and Colonel. Perceptions among grade levels and among organizations were compared as were the expressions of the climate the respondents would like to see prevail. Dr. Rensis Likert's questionnaire, "Profile of Organizational Characteristics", was utilized for data collection. In addition, several interviews with employees in all grade levels were conducted. The results of the analysis revealed different patterns of climate perception among individuals in each of the organizations. One functional organization recorded perception that exhibited significant differences among grade levels with individuals in the higher grade levels perceiving a climate that was more participative/democratic than that perceived by individuals in the lower grade levels. The other two organizations exhibited fewer differences among grade levels. There were few similarities among the organizations when the analysis was conducted for single grade strate. Additionally, individuals in all grade levels expressed a desire to move to an organizational climate that was significantly more participative/democratic than the one they had perceived.

137 A CRITICAL REVIEW AND COMPARATIVE ANALYSIS OF DEFINITIONS, CONCEPTS, AND STATE OF THE ART IN LITERATURE REGARDING SYSTEMS MANAGEMENT

Roger L. Williams, Capt, USAF | 77p | GSM/SM/71-14
Advisor: Dr. R. H. Klug | Lab Sponsor: ASD | AD 732934

In the last two decades the concept of systems management has been broadly applied and frequently treated in management literature. The rapid growth and expansion of the systems management concept has resulted in conflict and contradiction concerning its terminology, status, application, and philosophy. In view of the apparent conflict and contradiction, this research study was undertaken to develop and present a comprehensive review and comparative analysis of the literature concerning the systems management concept. The principle methodology applied was a review and critical comparison of secondary source data obtained mainly from libraries and correspondence with professional journals and associations. The definitions of a system and the systems approach were studied and compared as they appeared in the literature. Next the relationship of the systems approach and management was examined and the systems management concept viewed through its ancestry, present applications, and its future importance. The systems approach to management is based on a belief in orderly relationships and the interdependency and interaction of component parts and received its current inpetus as the result of twentieth-century trends in technological complexities. The systems management concept is a way of thinking and provides a model for better identification and understanding of relationships and interdependencies in a changing organization.

PART III

ABSTRACTS OF DOCTORAL DISSERTATIONS

138 A NUMERICAL METHOD FOR THE SOLUTION OF OPTIMAL CONTROL PROBLEMS WITH BOUNDED STATE VARIABLES

George R. Hennig, Maj, USAF — 91p — DS/EE/71-1
Advisor: Lt Col R. A. Hannen — Lab Sponsor: FJSRL

The numerical solution of nonlinear optimal control problems subject to nonlinear state variable inequality constraints and nonlinear terminal constraints is derived. The algorithm is a two step process. The first step is to seek a minimization of the cost functional based on the solution of a linearization of the problem. The second step is to restore the solution such that all nonlinear conditions are again satisfied. Compliance of the state variable inequality constraint is insured by directly determining appropriate components of the control vector. The inclusion of a parameter simplifies the numerical computation of variable time boundary conditions. The technique has application to analytical analysis of high performance vehicles that are subject to structural, environmental and human limitations which restrict the usable performance envelope.

139 SUBSET–SPECIFIED SEQUENTIAL MACHINES

Tom G. Purnhagen, Maj, USAF — 117p — DS/EE/71-3
Advisor: Lt Col F. M. Brown — Lab Sponsor: AMRL

In the design of sequential machines to perform specified tasks, situations sometimes arise in which the proper next-state or output entry in the flow-table is neither completely specified nor completely arbitrary. A machine having a flow-table of this type is called a subset-specified sequential machine (SSSM). It is not always possible to find a minimum-state realization of a subset-specified sequential machine using existing techniques for the state-reduction of incompletely-specified machines. A state-reduction procedure is developed for SSSM's which parallels the methods of Paull and Unger and of Grasselli and Luccio, and which reduces to these methods when the SSSM being reduced is an incompletely-specified machine. SSSM flow-tables are Boolean matrices, and can be manipulated as elements of a Boolean algebra. The idea of subset-specification is applicable to the modelling of certain types of learning processes, and to the analysis of systems exhibiting variable behavior or subject to uncertain inputs.

140 THE ELECTROSTATIC CONTROL OF PLASMA MICROINSTABILITIES

Richard M. Potter, Capt, USAF — 120p — DS/MA/71-1
Advisor: Dr. D. A. Lee — Lab Sponsor: ARL

Optimal control theory is applied to the problem of controlling electrostatic microinstabilities in a homogeneous electron plasma. The electrostatic microinstabilities are described by a linear integro-differential system of equations, the linearized Vlasov equations. In the class of additive distributed controls, a time varying electrostatic control produced by a control charge density is taken as a logical extension to the system equations. The region of control is considered fixed for a given problem. The linearized Vlasov system is reduced to a Volterra like integral equation relating the perturbed number density and the control density to an initial disturbance. A quadratic criterion yields a Fredholm like integral equation in the control density as a necessary and sufficient condition for optimality--the uncontrolled response serves as a driving term. An original generalized multiplier result yields an alternate "canonical" set of necessary equations. The necessary and sufficient equations are investigated for an isotropic and a two-stream electron plasma. The control region is taken to be all of configuration space so that spatial Fourier modes of the control density satisfy decoupled Fredholm integral equations in the time variable. The integral equations for the Fourier modes are reducible to linear two point boundary value problems which are numerically solved. It is observed in both cases that there is good suppression of the Fourier modes of the perturbed density ; interestingly, less control is required in the two-stream example. The physical significance of the examples studied appears limited. The limitations are discussed and suggestions are made for more physically interesting research.

141 AN EFFECTIVE STIFFNESS THEORY FOR ELASTIC WAVE PROPAGATION IN FILAMENTARY COMPOSITE MATERIALS

Rodney A. Bartholomew, Capt, USAF — 240p — DS/MC/71-1
Advisor: Dr. P. J. Torvik — Lab Sponsor: AFIT

An approximate first order theory for elastic wave propagation in composite materials composed of long fibers of rectangular cross section embedded in a soft matrix is developed. Included are stress and displacement equations of motion, boundary conditions, and constitutive relations. Higher order stresses are related to average conventional stresses and moments of stresses. The boundary conditions are shown to be averaged forms of Cauchy's law of classical elasticity. Procedures for reducing the theory to that of classified elasticity and that for laminates are established. In addition, displacement equations of motion for a limited second order theory for flexural motion are presented. For propagation parallel to the fiber orientation in an unbounded medium, the motion separates into three distinct types: longitudinal, flexural, and torsional. All motions are dispersive and are sensitive to changes in relative material stiffnesses and geometry. For propagation perpendicular to the fiber orientation, the motion is dispersive and frequency spectra show stopping bands typical of periodic media. The propagation of plane waves parallel and perpendicular to the fiber orientation in an infinite plate is investigated for the case of plane strain. Resulting spectra strongly resemble those of homogeneous, isotropic plates and show the same general sensitivity to material parameters as the infinite body results.

142 AN INVESTIGATION OF THE MECHANICAL BEHAVIOR OF METALS AT HIGH STRAIN RATES IN TORSION

John E. Lawson, Maj, USAF — 161p — DS/MC/71-2
Advisor: Maj William Goldberg — Lab Sponsor: AFML

A Torsional Split Hopkinson Bar Testing System was developed and analyzed for the existence of higher mode strains in the two elastic bars. The testing device was used to obtain high strain rate data for Aluminum 1100-0, Aluminum 2024-T3 and Titanium 50A. Using the Aluminum 2024-T3 an investigation into the effect of specimen gage length was carried out and from the data for Titanium 50A a plastic strain rate expression of the exponential type was deduced. This expression was used in a numerical plastic wave study and the results compared with the equivalent actual experiments. The effect of changing the constants in the plastic strain rate expression was also investigated.

143 SOME THEORETICAL ASPECTS OF NONZERO SUM DIFFERENTIAL GAMES AND APPLICATIONS TO COMBAT PROBLEMS

Anthony L. Leatham, Capt, USAF — 102p — DS/MC/71-3
Advisor: Maj G. M. Anderson — Lab Sponsor: AFFDL

The theory of nonzero sum differential games (NZSDG) is extended for a class of problems in which the nonlinear system equations have bounded control variables appearing linearly. For terminal cost functions this class of problems is shown to exhibit "bang-bang" type control laws with the possibility of singular controls. A condition is derived to test for continuity of the influence functions when controls switch from a nonsingular to a singular control on singular surfaces. Two generalized forms of the transversality conditions are derived from NZSDG theory extending results of Dreyfus and Isaacs. NZSDG theory is shown to be useful in modeling combat problems in which the goals of the players are not diametrically opposed. A two player and a three player penetrator-interceptor problem are presented as a NZSDG. Numerical solutions for a totally singular problem are carried out to illustrate application and a typical solution. A two player NZSDG pursuit-evasion problem is analyzed in which the cost functions of the two players are different functions of the terminal range and angle off.

144 AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE ODD-PARITY SPECTRUM OF THE Cl^{34} NUCLEUS

Anthony K. Hyder, Jr., Capt, USAF — 123p — DS/PH/71-1
Advisor: Dr. Richard Hagee — Lab Sponsor: ARL

An experimental and theoretical study of the odd-parity states in Cl^{34} has been made to identify major components of the $1d_{\frac{3}{2}} - 1f_{\frac{7}{2}}$ and $1d_{\frac{3}{2}} - 2p_{\frac{3}{2}}$ spectra. Resonances in the S^{33} (p, γ)Cl^{34}

reaction at proton energies of 1058, 1098, and 1121 keV were investigated using an 80 cm^3 Ge(Li) detector. A revised Q-value, Q = 5139.9 ± 0.9 keV, and the excitation energies of fourteen bound levels, 2.3 MeV ≤ E_x ≤ 4.7 MeV, were obtained, and decay schemes of the three resonance levels and eleven odd-parity bound states were deduced from the gamma-ray spectra. The spins of several odd parity levels were also determined from gamma-ray angular correlation measurements. A six-particle shell-model calculation yielding energies and wavefunctions of odd-parity levels in mass-33 and mass-34 nuclei was also performed. Nucleons in the $2s_{\frac{1}{2}}$, $1d_{\frac{3}{2}}$, $1f_{\frac{7}{2}}$, and $2p_{\frac{3}{2}}$ orbits were coupled to an inert Si^{28} core with the restriction that no more than $2s_{\frac{1}{2}}$ nucleons would be excited to higher orbits. The modified surface-delta interaction was used. The experimental and theoretical results are compared, and levels which are proposed as members of the two-nucleon spectra are discussed.

145 ELECTRON EMISSION STUDIES OF THE IIB-VIA SEMICONDUCTOR COMPOUNDS

Charles J. Vesely, Capt, USAF — 88p — DS/PH/71-2

Advisor: Dr. R. L. Hengehold — Lab Sponsor: ARL

X-ray induced electron emission measurements were used to determine the energy levels of core electrons in ZnO, ZnS, ZnSe, ZnTe, CdO, CdS, CdSe, CdTe, HgS, HgSe and HgTe. The investigated energy range extends from the bottom of the valence band (6-8 eV below the Fermi level) to about 1200 eV below the Fermi level. Chemical shifts were determined by comparing the results of these measurements with experimental values for the pure elements. These shifts are plotted as a function of the fractional ionicity values determined by Phillips and Van Vechten, Pauling and Coulson. Core level values for ZnSe and CdTe are compared with self-consistent relativistic orthogonalized plane wave calculations for the excitation energies of these compounds. Agreement with these theoretical calculations is best for the levels closest to the valence band and appears to be angular-momentum dependent. For the first time, spin-orbit splitting values were experimentally determined for several levels including Zn, 3d, Cd 4d and Hg 5d levels. The measured energy values for the upper d-levels are compared with values obtained by ultraviolet induced electron emission, ultraviolet reflectivity and electron energy loss measurements.

146 DETERMINATION OF SPATIAL AND TEMPORAL ELECTRON DENSITY AND TEMPORAL ELECTRON TEMPERATURE IN LASER-PRODUCED GASEOUS DEUTERIUM PLASMAS

Winston K. Pendleton, III, Capt, USAF — 124p — DS/PH/71-3

Advisor: Dr. A. H. Guenther — Lab Sponsor: AFWL

The temporal and spatial electron density distribution and the temporal variation of electron temperature have been determined in gaseous deuterium plasmas produced by a laser. In addition to these measurements, made during laser irradiation of the plasma, the plasma growth rate, laser-plasma absorption and reflection interaction, and pressure dependence of laser intensity breakdown threshold have been determined. The laser intensity breakdown threshold is shown to have a nearly inverse pressure dependence establishing the dominance of pulse duration over diffusion or recombination in the attainment of breakdown. Asymmetric growth rates of 4×10^7 cm/sec toward and less than 10^6 cm/sec away from the laser coupled with a maximum of 16 percent energy densities corresponding to 25 percent ionization (4×10^{18} to 1×10^{19} electrons/cm^3) and electron temperatures of 4×10^5 °K shows the plasma as a whole to be highly nonequilibrium even though the electrons and deuterons remain respectively thermalized. The refractive and reflective effects of the plasma boundary were calculated and reflection was determined as responsible for the strong ruby emissions observed at 90°. A time-variable reflectivity (TVR) ruby laser with a pulse duration of 4 nanoseconds was employed in these experiments at gas pressures from 100 to 600 torr. The electron density and temperature measurements represent a major addition to the data available on laser-produced plasmas.

147 A METHOD OF MEASURING JET EXHAUST DENSITY PROFILES USING SOFT X-RAYS

Robert P. Couch, Capt, USAF — 78p — DS/PH/71-4

Advisor: Col E. L. Battle — Lab Sponsor: AFFDL

A new method suitable for measuring the density profile in a jet exhaust has been devised. The method is based on the transport properties of soft X-rays. The use of uncollimated detectors, capable of receiving flux over 2π steradians, simplifies the experimental aspects of any application and results in a large reduction in the required source intensity. The transport approach does, however, require that a more sophisticated data analysis technique (unfolding) be used. A general

analytic method for predicting the X-ray fluxes reaching the detectors has been developed and tested using Monte-Carlo methods. Simplified methods have been found to reduce the data in various density regimes and the unfolding method has been tested experimentally on a device which simulated a jet exhaust density profile with heated air. The X-ray density method compared within about 1% to a standard technique. Methods of using the density profile of a jet exhaust to compute (inflight) gross thrust are treated. It is shown that the gross thrust is nearly linear in the product of exhaust density and total temperature and that the gross thrust has a reasonable sensitivity to exhaust density.

148 RADIATION DAMAGE EFFECTS IN ELECTRON IRRADIATED CADMIUM SULFIDE PLATELETS AT LOW TEMPERATURE

C. Neale Elsby, Maj, USAF — 130p — DS/PH/71-5
Advisor: Dr. R. L. Hengehold — Lab Sponsor: ARL

A study was made of the luminescence properties of cadmium sulfide platelets which were bombarded at near liquid helium temperature with fast electrons at energies above 100 keV. Photoluminescence and cathodoluminescence spectra were evaluated. Post-irradiation annealing and thermal and optical quenching experiments were conducted. Bound-exciton luminescence decreases in intensity with irradiation with the exception of a line near 4867Å which was enhanced in some samples. Annealing to 300°K causes partial restoration of luminescence. Theory indicates that the luminescence decreases because of trap production and exciton-center destruction. Broad-band luminescence is produced at 5180A and 1.12μm during low temperature irradiation. Luminescence at 5140Å, 7300Å, and 1.65 – 2.0 m is reduced during irradiation. Annealing to 300°K removes the 1.12μm luminescence, restores the 5140Å and 1.65μm bands and results in the production of a strong band at 7330Å. Annealing experiments suggest that defect migration occurs in several stages between 80°K and 300°K. Activation energies of 0.22 – 0.30 eV are assigned to interstitial migration. An energy level model is presented to describe the luminescence bands. A displacement threshold for the cadmium atom is found to exist at 314 (±5) keV. Broad band luminescence changes are interpreted as being caused by simple defect production.

149 COMPTON SCATTERING FROM A RELATIVISTIC MAXWELLIAN DISTRIBUTION OF ELECTRONS BY THE DISCRETE S_n METHOD

Brian G. Stephen, Capt, USAF — 117p — DS/PH/71-6
Advisor: Dr. C. J. Bridgman — Lab Sponsor: Defense Nuclear Agency — AD747485

This research effort determined how to numerically represent the scattering kernel for X-ray scattering from a relativistic Maxwellian distribution of electrons in a multigroup discrete S_n treatment of the equation of radiative transfer. Ten sets of 134-group averaged Wien weighted cross section coefficients were calculated for electron temperatures between 0.5 and 20 keV, with photon energies between 0.05 and 400 keV. These 134-group cross sections were then collapsed to ten, twenty, and forty group cross section sets for use in parametric transmission studies using a discrete S_n transport code. Steady state transmission studies in which the source and electron temperatures were equal showed that the kernel is adequately represented by a two-term Legendre polynomial expansion. In optically thin regions an S_8 angular quadrature is sufficient for near-isotropic sources while S_{16} or higher quadratures are necessary for highly anisotropic sources. Steady state transmission studies in which the source temperature did not equal the electron temperature, but in which the cross sections were deliberately weighted by an equilibrium photon distribution, indicated that for 20 or fewer energy group models the ratio of source temperature to electron distribution temperature must lie in the interval $0.8 \leq T/T_e \leq 1.8$ if spectral errors are to be limited to five percent or less.

150 THE PRINCIPAL AXIS COORDINATE SYSTEM APPLIED TO DIFFRACTION OF ELECTROMAGNETIC RADIATION BY WEAK SONIC VIBRATIONS IN AN ANISOTROPIC MEDIUM

Michael F. Baran, Capt, USAF DS/PH/71-7

Advisor: Dr. Bernard Kaplan Lab Sponsor: AFWL AD 734753

It is well established that under certain general assumptions concerning an anisotropic medium, the constitutive relations associated with Maxwell's equations may be represented as a linear effective permittivity tensor. When electron collisions may be treated with a single effective collision frequency, this tensor is normal, and leads to a basis for a complex mathematical three-space related to the anisotropy of the medium. Maxwell's equations are defined in this system, and by use of the general contravariant and covariant tensor formalisms, the necessary dual coordinate bases and vector relations are established eliminating the need for ad hoc assumptions used by previous authors. The principal modes of propagation in the medium are then easily found and the classic Appleton-Hartree equation is derived. A necessary condition for the existence of solutions to propagation problems is developed. This leads to two independent, second-order scalar equations for transverse propagation subject only to the restriction that the medium properties be constant along the axis of anisotropy. An original solution to the diffraction of a transverse (to the static field) electromagnetic wave by a transverse sonic variation in an anisotropic half-space is obtained, limited only by the Bragg condition. The symmetry of the forms of the equations in the principal coordinates facilitates the analysis. The first order results show that the extraordinary (TE_3) mode diffraction is affected by the anisotropy, and for certain values of the medium parameters, the effects are large. To the same order, the ordinary mode diffraction is a function only of the isotropic electron density. A qualitative explanation for these effects is offered, based on the interaction between the electrons and the static magnetic field which produces the anisotropy of the medium.

PART IV

INDEX OF SPONSORING ORGANIZATIONS

Air Defense Command (ADC)
Air Force Avionics Laboratory (AFAL)
Air Force Cambridge Research Laboratory (AFCRL)
Air Force Flight Dynamics Laboratory (AFFDL)
Air Force Flight Test Center (AFFTC)
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Air Force Weapons Laboratory (AFWL)
Aerospace Medical Research Laboratory (AMRL)
Aerospace Research Laboratories (ARL)
Aeronautical Systems Division (ASD)
Frank J. Seiler Research Laboratory (FJSRL)
Rome Air Development Center (RADC)
Space and Missile Systems Organization (SAMSO)

PART V

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