Abstracts of Papers from Scientific Program of 1961 Meeting of Aerospace Medical Association, Chicago, April 24-27

Prolonged Human Performance as a Function of the Work-Rest Cycle.

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The problem of prolonged work-rest schedules is an important one for the military planner who seeks to optimize overall man-machine system performance by maximizing operator proficiency and minimizing manning requirements. This paper describes a study designed to investigate the feasibility of a 4-hours-on-duty and 2-hours-off-duty schedule. Two B-52 combat crews were confined for fifteen days in an advanced system crew compartment mockup and tested with a battery of five performance tasks and four psychophysiological measures. Results indicate that men are able to work for periods of at least fifteen days using a 4-on and 2-off work-rest schedule continuously without any marked change in performance efficiency or in psychophysiological functioning.

EEG in Relation to Pilot Incidents and Accidents.

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EEG deviations from normal in pilots who are involved in incidents or accidents in flight are compared to baseline EEGs on 1332 Naval Aviation Candidates, some of whom also became part of the incident-accident group because of subsequent mishaps. The incidents consisted of episodes of unconsciousness including several accompanied by motor seizures. Of the large survey baseline group the tracings which would be considered borderline to abnormal by the most rigorous standards comprised approximately 14 per cent of the total. Those showing at least minimal paroxysmal tendencies comprised less than 4 per cent of the total. In contrast, the smaller number of individuals in the incident-accident group, judged by the same standards, show 61 per cent with some deviant signs and approximately 30 per cent with at least minimal paroxysmal tendencies. The relative incidence of several types of deviation will be discussed. In an effort to find a means of activating abnormal tendencies and thus to provide a basis for elimination of potentially dangerous aviation candidates, EEG has been recorded during a standard acrobatic sequence in a piston engine aircraft, the subjects being flown as passengers. Among the subjects in this experiment are aviators and nonaviators known to have normal EEGs and other aviators who have had some type of unconscious episode while piloting aircraft. The stressful flight sequence activated EEG abnormalities in a high percentage of the second group in contrast to a very low percentage in the normal group. Tracings and movies of the subjects during flight sequence will be shown.

A Significant Development in Light Weight Arctic and Wet Weather Clothing.

SQ. LDR. S. E. ALEXANDER, RCAF, Institute of Aviation Medicine, Toronto, Canada.

Military activity in Arctic winters has been seriously hampered by the weight and bulk of protective clothing. The Institute adopted the Eskimo concept of clothing as the criterion towards the development of light weight synthetic materials. This resulted in the production of a waterproof nylon fabric, treated with polyurethane, that is air impermeable but offers sufficient vapour diffusion to dissipate body moisture. A pure nylon fleece was also developed which provides the necessary insulating liner as well as material for duffle socks. New light weight mukluks were designed, producing a garment complex offering better protection at one-third the weight.

The Selection of Potential Astronauts.

ROSALIE AMBLER, M.S., J. R. BERKSHIRE, M.A. and LIEUT. W. F. O'CONNOR, MSC, USN, USN School of Aviation Medicine, Pensacola, Fla.

Since June 1959 all naval air trainees have been given the opportunity to volunteer for astronaut training. This study compares the aptitudes and abilities of those who volunteer with those of the Mercury Astronauts, with the final group of 31 from which the Mercury Astronauts were drawn, and with men who did not volunteer. Of 1350 trainees studied 330 volunteered. On tests of intellectual and technical ability 24 per cent of the volunteers scored within the range of abilities displayed by the Mercury Astronauts, and 48 per cent scored within the range of the 31 man Mercury group. The volunteers were superior to non-volunteers on parameters of aptitude, pre-flight performance, flight, and motivation. The advantages of early selection and implications for longitudinal study are discussed.

Studies on the Biodynamic Potential of Air Traffic Management Personnel: An Interdisciplinary Approach.

BRUNO BALKE, M.D., FAA Civil Aeromedical Research Institute, Oklahoma City, Okla.

Safety of flying depends greatly upon the most efficient control of air traffic. Professionals engaged in this type of work encounter numerous stress situations affecting their mental and physical alertness. Before studying the biologic responses of air traffic controllers directly under demanding job conditions an appraisal of their psychophysiologic potential appeared indicated. Such a study was expected to show group characteristics different from, or similar to, other groups of interest in aviation. Work capacity and fatigue resulting from a defined working period were determined by established physiological and biochemical criteria. A series of anthropometric measurement was taken and the psychological structure was evaluated by a complex test battery. The data obtained are directly applicable for estimating the potential capacity for daily work requirements and serve as the basic background for an intended longitudinal investigation of air traffic control personnel.

Bioengineering of Advanced Life-Support Systems.

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Circumlunar vehicles and space stations of the near future will contain new types of life-support systems in order to minimize take-off mass. Because of their relative complexity, these systems will require extensive development efforts to obtain the optimum man-machine system. This paper describes the system considered best for mission durations of one or more months, and the status of our development efforts. Experimental models of (1) a compression distillation water recovery system, (2) reduction-electrolysis oxygen regeneration system, (3) cabin gas conditioning system, (4) waste collection and storage system and (5) vacuum distillation water recovery system have been constructed and preliminary tests performed. Primary emphasis in these developments has been placed on determining the control and maintenance problems. The systems as described are automated to the fullest extent possible, and contain displays for trouble shooting and manual operation. Future development efforts will require the use of an environmental system simulator so that tests of the man-machine complex can be performed for prolonged durations. This paper describes such a simulator capable of sustaining three men for duration of one or more months, which is now under development in our laboratories.

An Assessment of a Real Isolation Experience and its Implications for Manned Space Flights.

Capt. George W. Barnard, USAF (MC), Aerospace Medical Division, Wright-Patterson AFB, Ohio.

This report gives a descriptive and analytical recount of Richard Byrd's experience during the four and one half month period he was alone at the Antarctic. The similarities between this real life stress situation and that anticipated by man during prolonged space flights are given. A psychiatric evaluation of Byrd's experiences and reactions is made with an attempt to better understand the changes which occur with isolation, monotony and loneliness. Emphasis is placed on discovering the critical personality variables and defense mechanisms which are most effected and the protective maneuvers which may be employed to prevent psychological deterioration.

Pulmonary Function Evaluation in Air and Space Flight.

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Ideal monitoring of pulmonary function allows constant surveillance of the pilot or Astronaut with a minimum of equipment. A velocity-volume (V-V) loop synthesized from a pneumotachogram permits the assessment of the following measurements: vital capacity, tidal volume, expiratory reserve volume, inspiratory reserve volume, inspiration capacity, air trapping, "timed" inspiratory and expiratory vital capacities, breath accelerations, inspiratory and expiratory reserve velocities, and peak inspiratory and expiratory velocities. Also, the contour of the V-V loop is, in itself, significant. In addition, the maximum breathing capacity at any breathing frequency may be very reliably predicted from the V-V loop. All that is required for these several measurements is a pneumotachograph, a transducer, appropriate read-out, and a momentarily voluntarily altered breathing pattern.

Inflight Rupture of the Tympanic Membrane Secondary to Exostosis of the External Auditory Canal.

Lt. Col. Stanley H. Bear, USAF (MC), USAF Hospital, Wiesbaden, Germany.

Exostosis of the external auditory canal is a benign process and not an uncommon finding in flying personnel. A sudden barometric pressure change may produce enough pressure differential between the external canal and middle ear cavity to result in the spontaneous rupture of the tympanic membrane. Two cases of inflight rupture are reported. One occurred in a pilot during descent of an F-100 jet aircraft, and the other in a physician while a passenger in a conventional aircraft. The various etiologic factors and the physiology of the external and middle ear are discussed. Treatment consists of the surgical removal of the exostosis. The individual can usually be rehabilitated and returned to flying status without symptoms or sequelae.

Some Physiological Changes Observed in Human Subjects During Zero G Simulation by Immersion in Water up to Neck Level.

Capt. Ed. L. Beckman, MC, USN, Lt. Comdr. Kenneth R. Coburn, MSC, USN, Randall M. Chambers, Ph.D., Lt. Comdr. R. E. DeForest, MC, USN and Capt. V. G. Benson, MC, USN, Aviation Medical

Acceleration Laboratory, USN Air Development Center, Johnsville, Pa., and CAPT. WILLIAM AUGERSON, MC, USA, National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

Knowledge relative to the effects of prolonged weightlessness is needed in preparing man for space flight. The buoyant force exerted upon immersed bodies effectively simulates the weightless state with respect to proprioceptive sensory responses and perhaps in other ways. An investigation into the physiological effects of immersing subjects in water up to neck level was undertaken. It was found that water immersion creates an unnatural physiological situation in that during respiration the inspired air pressurizes the lungs to atmospheric pressure while the external pressure against the chest, abdomen and legs is greater than atmospheric due to the water pressure. This situation is equivalent to "negative pressure breathing." A series of experiments involving seven subjects immersed in water up to neck level for periods of 5-23 hours (five subjects for 12 hours) showed a significant weight loss during the period of immersion, which was explained by the diuresis which occurred. Pulmonary gas volume measurements showed a decrease in the expiratory reserve volume and in the respiratory minute volume during immersion. There was no significant decrement in the performance of a tracking task during exposure to a simulated space vehicle reentry acceleration profile which was attributable to the water immersion. Exposure to 4.5 positive G for 15 seconds following water immersion revealed a decrement in tolerance in most subjects.

The Mars Bluff Case—A Medicolegal Case History in a Nuclear Weapons Incident, Florence, South Carolina.

BRIG. GEN. T. C. BEDWELL, JR., COL. ALVIN F. MEYER, JR. and MAJ. HUGH B. MITCHELL, JR., USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

On March 11, 1958, a nuclear weapon was inadvertently released from a B-47 aircraft flying in the vicinity of Florence, South Carolina. The bomb landed on a farm in what is known as the Mars Bluff community. As a result of the damage to buildings from detonation of a high explosive component from the weapon (there being no nuclear yield), the government offered to pay damages which were refused and a suit resulted. In addition to the claims for physical damage to property, essential allegations of the plaintiffs included apprehension regarding the presence of radioactive material, possible exposure to ionizing radiation, hearing loss due to blast effects, and other physical injuries resulting from the blast. The authors, as members of the Headquarters Strategic Air Command Disaster Control Team and recognized as having a high degree of competence in the professional areas concerned, were requested by the US Attorney's Office to serve as expert witnesses for the government. The assistance given the US Attorney in preparing background material for the case, the development of questions, and the conduct of the trial itself, with special emphasis on the medical and public health connotations, are described. The case was decided in favor of the government in that allegations regarding radiation exposure apprehension were ruled as not justified and the amount of damages allowed was less than those originally offered by the government. While this case report deals primarily with a nuclear weapons incident and the problems of alleged radiation in weapons effects, it typifies the problems that almost any flight surgeon or medical service officer may come in contact with as the result of aircraft accidents, missile accidents, or other catastrophic occurrences caused by government operations.

Human Forward Facing Impact Tolerance.

CAPT. ELI L. BEEDING, JR., USAF (MSC), Air Force Missile Development Center, Holloman AFB, N. M.

A total of fifteen human tests were done on the Daisy Decelerator in this series, in which the subjects experienced "eyeballs out" decelerations. Force levels ranged from 30-40 G at rates of onset from 500-1100 G per second for total durations on the order of .075 seconds. The series was terminated at the 40 G level when a subject suffered three vertebral compression fractures. This series of experiments is discussed in detail and comments made as to possible causes of this rather low tolerance limit.

Biological Effects of Magnetic Fields.

DIETRICH E. BEISCHER, Ph.D., USN School of Aviation Medicine, Pensacola, Fla.

The behavior of living material in strong magnetic fields is of basic interest as a possible form of extreme environmental stress in space travel. Moreover, it may be of future technical interest in connection with magnetic thrust propulsion systems. The physicochemical principles of magnetochemistry will be explained in connection with a presentation of our kinetic studies of enzyme systems *in vitro*. The action of magnetic fields on living matter will be demonstrated using the examples of the life cycle of Drosophila, the cell division of sea urchin eggs and yeast. The results of an inquiry concerning accidental exposure of man to the magnetic field of cyclotrons will conclude the report.

Effects of Prolonged Total Body Water Immersion on Human Tolerance to Positive Acceleration.

CAPT. VICTOR G. BENSON, MC, USN, CAPT. EDW. L. BECKMAN, MC, USN, and LT. COMDR. KENNETH R. COBURN, MSC, USN Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Experimental data available suggests that tolerance to the accelerations of space vehicle re-entry is decreased following a period of weightlessness. The

weightless or zero "G" state encountered in orbital flight can be simulated in a laboratory to a degree by completely immersing the subject in water. A study of this nature was undertaken at the Aviation Medical Acceleration Laboratory, utilizing the assistance of twelve divers from the Underwater Demolition Team Number 21, Amphibious Forces, Atlantic Fleet. The tolerance to positive acceleration of these subjects was measured and mean values were determined prior to water immersion. All subjects were then totally immersed in water for a period of 18 hours. Their tolerance to positive acceleration was measured immediately after the period of water immersion and again after 24 hours recovery. With one exception, there was a decrease in tolerance to positive acceleration immediately following the period of water immersion. However, the magnitude of this decrement was within the range of daily variation in G tolerance of normal subjects.

The Physiological Control of Human Body Temperature. T. H. BENZINGER, M.D., Ph.D., Naval Medical Research Institute, Bethesda, Md., A. W. PRATT, M.D., National Institutes of Health, Bethesda, Md., and C. KITZINGER, M.D., Naval Medical Research Institute, Bethesda, Md.

By rapid and continuous measurements of cranial internal and skin temperature, by direct rapid recording of oxygen consumption rates and by gradient calorimetry of sweating and peripheral circulation, the quantitative relations between stimuli and responses in the two systems of physical (in warm environment) and chemical (in cold environment) control of human body temperatures have been measured. With drastic measures destroying coincidental correlations between internal cranial and skin temperatures, it was found that sweating, and probably also vasodilation, is elicited by the *internal*, not the cutaneous thermoreceptive system. On the other hand, *chemical* control by increased metabolic rate and shivering was identified as a response to skin cold-receptor impulse-frequency. This demonstrates basically different operational characteristics of the two mechanisms for defense against *heat*, located in the *anterior* hypothalamus and for defense against *cold*, located in the posterior hypothalamus. The *posterior* hypothalamic center found by others to be indifferent to thermal stimulation functions as a synaptic relay station. The anterior hypothalamic center found by others to elicit, upon *warm* stimulation, the thermoregulatory responses of sweating and vasodilation and to inhibit shivering must be considered a terminal sensory organ with first neurons for temperature comparable to the retina, terminal sensory organ for light, unless new and hitherto unknown cranial internal thermoreceptor fields will be discovered.

Improved System for Liquid-Gaseous Phase Partition in Space Vehicle Environmental Control. LIEUT. JAMES H. BERRIAN, MSC, USN, Bio-Environmental Division, USN Missile Center, Point Mugu, Calif.

Altered gravitational forces encountered in missile and space flight, ranging from high acceleration to weightlessness, present certain special problems in chemical systems engineering that do not find fully satisfactory solution in past state-of-the-art technology. One such problem concerns manipulations of binary phase, liquid-gaseous mixtures. Under space flight conditions, it cannot be assumed that phase boundaries will remain predictably oriented within their containers. The displacement of one phase (gaseous or liquid) from a vessel containing the other phase is a typical problem encountered in distillation, evaporative heat exchange, and other processes within environmental control and life support systems. The present communication will describe novel system elements and their operating characteristics that provide an attractive solution to the problem. The devices to be shown are essentially thermal conductive filters that pass liquids in the presence of gases, with the exclusion of gaseous phase. Unlike most other proposed methods, operating energy, weight, space, and moving parts are minimized with a gain in efficiency and reliability. Environmental control systems incorporating the elements will be discussed.

Space Programs and the Future. LT. COL. CHARLES A. BERRY, USAF (MC), Aerospace Medicine Division, Office Surgeon General, USAF, Washington, D. C.

The development of the rocket as a vehicle has placed man in the position to explore space. This can be done only with proper aerospace medical support whether the missions are exploratory or operational USAF projects. Aerospace medicine specialists find themselves in a rapidly moving transition period where much emphasis is placed on the "race to space" but apparently fewer flight surgeons are involved. In reality the support of space programs may require as many or more full time but better trained flight surgeons. The role of the flight surgeon in support of current future space programs is discussed with emphasis on selection, maintenance, protection and monitoring.

Weight Control—A New Air Force Program. LT. COL. DAVID H. BEYER, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

The USAF has paid increasing attention to physical fitness and obesity, particularly in relation to the aging pilot population, resulting in an Air Force-wide Obesity Control Program. The effectiveness and various problems of obesity control are discussed in this paper with particular reference to the import of the new standards of height-weight which more closely correspond to those recommended by major life insurance companies.

Snail Haemolymph as a Source of Food and Water in Desert Survival.

FLT. LT. J. BILLINGHAM, RAF Institute of Aviation Medicine, Farnborough, England.

In the scrub desert of Northern Cyrenaica there exists many areas where a white snail, Eremina Ehrenhergi Roth, is to be found in millions. If the shell is smashed haemolymph escapes. Analysis of this fluid showed it to be promising as a source of water for a survivor in the desert. Furthermore, it contained protein in a concentration of 38 gms. per liter. It did not contain pathogens harmful to man and was given to rats as their only source of water without ill effect. A subject consumed 8,880 ml. of haemolymph obtained from 4,400 snails over a period of four days. He took no other food or fluid and was exposed each day for six hours in a hot chamber at 118° F., simulating a moderately hot desert climate. The subject suffered only a little weakness from the enforced dieting and from the voluntary partial dehydration. Analysis of the urine showed that there was no ketosis. The subject remained mentally alert and lived a normal life during the experiment. Aircrew lost in the desert without water would have been moribund or dead at the end of four days.

Medical and Environmental Problems of Aerial Applicators.

CHARLES E. BILLINGS, JR., M.D., Ohio State University, Columbus, Ohio.

The medical problems involved in aerial application are to a considerable extent unique in aviation. Though other aviators are exposed to reduced pressure, hypoxia and cold, aerial applicators encounter neither low pressure nor hypoxia, and more commonly deal with severe heat than with cold. Windblast, certain visual illusions and noise are among the problems encountered. Fatigue is a constant problem during periods of peak activity, when flying may continue day and night for weeks without letup. Pilots are exposed to a variety of chemicals, some acutely toxic, others insidious in their effects. The flying task demands great skill in handling heavily loaded aircraft whose performance may be marginal, yet instrumentation and other aids to the pilot are almost nonexistent. Medical coverage in this field is entirely inadequate. While some improvement in aircraft design has resulted from accident studies, the most popular applicator airplanes are older types without such improvements. The potential hazards of this work demand considerable study from the aeromedical and human factors viewpoints. Some potentially profitable approaches to these problems will be discussed.

Shape Perception Under Near Threshold Conditions.

M. BITTINI, M.D., A. M. ERCOLES, M.D., A. FIORENTINI, M.D. and L. RONCHI, M.D., Istituto Nazionale di Ottica, Arcetri-Firenze, Italy.

A recent investigation has shown that the contrast-perception probability function is irregular (the contrast-perception probability has an irregular behavior) when the luminance of the background against which the small test patch is presented varies in the mesopic (twilight) range. The relationship between *shape-perception* probability and background luminance in the said range has now been investigated and an attempt has been made to correlate the results of the present investigation with the irregularities (dips and humps) of the contrast-perception probability curves. The differences between shape-perception probability curves obtained with different colors of the test field seem to be significant. In addition, the role of eye movements in shape-perception has been investigated. The shape of a target whose image is stabilized on the retina varies with time: the shape variation has been studied both for dark target on a bright background and for a bright target on a dark background. The results are compared and discussed. From a practical standpoint the data reported might give an indication of the role of shape-perception in the recognition of signals.

Scientific Evaluation of Oxygen Systems for Civil Transports Flying Above 40,000 Feet.

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Under the sponsorship of the Civil Air Surgeon's Office of the Federal Aviation Agency, an intensive four months' study was undertaken to establish the state of knowledge and opinion in the field of oxygen protection requirements for civilian air transports designed for flight in the 40,000 to 50,000 foot range. This paper presents a critical analysis of the data collected in the course of personal visits to the centers where research has been done in recent years bearing on this problem and reviews the results of a working conference attended by seven of the active research workers in the field. The consensus of this conference represents a proposal to expedite and coordinate the acquisition of essential physiological information bearing on the requirements for protecting unselected civilian passengers from the serious effects of decompression at very high flight altitudes. Included is a delineation of the questions requiring priority consideration for experimental investigation in international, inter-service, interdepartmental, cooperative programs to achieve the optimum utilization of all available scientific talent and experimental facilities.

Factors Related to Selective Fitting Aviators' Oxygen Breathing Masks.

AARON BLOOM, B.S.A.E., Sierra Engineering Company, Sierra Madre, Calif.

Oxygen breathing masks are designed primarily for delivering supplemental oxygen to the pneumothoracic area of the subject. This paper deals with

those factors directly affecting the fit and use of aviators' oxygen breathing masks. Mechanical designers can very effectively predict the physical configuration of an infinite variety of mechanisms, ducting, etc., for delivery of supplemental oxygen. Further, it is only a matter of concentration to design an oxygen breathing mask to satisfy the contours of any given size face. However, unless the breathing mask is installed on the man's face properly, and a suitable sizing technique is used, the effectiveness of the oxygen breathing mask is minimized to the point of insidious danger to the subject. An improperly fitted mask, although comfortable, in most cases will reduce the efficiency of a given oxygen breathing system below safe physiological limits. A number of physical, physiological, and anthropometric variables and controls will be discussed and defined.

Naval Aircraft Escape Systems—Past, Present and Future.

CAPT. ROLAND A. BOSEE, MSC, USN and C. T. KOOCHEMBERE, Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Escape systems as defined in this paper encompass the ejection seat concept as applied to naval operational and training type jet aircraft. It is also applicable to those escape systems that have been considered for vertical takeoff and landing (VTOL) types. The evolution of seat and seat catapult design as well as performance capabilities are described as they relate to post World War II naval aircraft. The need for increased ejection trajectory height to assure ground level escape is documented. Test and development relative to some early escape capsule designs as well as a description of some energy attenuation systems are presented. The transition from sixty feet per second to eighty feet per second ejections in conventional seat catapult is explained. The effect of acceleration as applied to seat occupant and equipment is described. The design and function of rocket-type ejection seat systems for more advanced type manned military aircraft and tests to assure performance, reliability and personnel compatibility are also set forth. Finally, an experimental integrated flight capsule concept is described in which a shaped charge is used to cut the capsule away from the remainder of the aircraft.

Space Age Utilization of Recycled Metabolic Wastes.

CAPT. ROLAND A. BOSEE, MSC, USN, PERRY R. TILLER, M.A., LOUIS J. SANTAMARIA, B.S. and NEAL M. BURNS, PH.D., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

For a period of six days, the sole beverage received by one subject was urine, recycled by the General Electric high temperature oxidation device. Prior to drinking, the recycled urine was checked for odor, pH, color, and taste. The subject's urine was routinely analyzed at periodic intervals for any marked changes. A complete blood count, serum sodium, and potassium determinations were also performed. Results show that there were no deleterious effects on the subject during or after the experiment. The recycled urine was reported to be colorelss, odorless, tasteless, biologically inert, and generally met with the United States Public Health Service standards for drinking water.

Problems in Aeromedical Support of Flight Test Programs.

MAJ. HARRY R. BRATT, USAF (MC), Director of Base Medical Services, Edwards AFB, Calif.

A review of aeromedical facilities and activities in support of flight test operations at the Air Force Flight Test Center, Edwards AFB, California, is presented. These facilities consist of the usual Air Force base medical complex, the sixteenth Physiological Training Flight, and the Human Factors Branch of the Flight Test Engineering Laboratory. The activities of these three facilities are closely coordinated in support of diverse test operations which involve the Air Force, Navy, Army, NASA, civilian contractors, and on occasion, foreign nationals in testing of conventional aircraft, advanced vehicles, and rocket engines. The Human Factors Branch has been the primary agency for the bio-medical input to flight test programs, particularly the X-15 program and planning for Dyna-Soar. In its supporting role, the sixteenth Physiological Training Flight has developed an outstanding capability in the field maintenance and repair, and modification and development of full pressure suits, as a result of the field testing and operational experience with this equipment.

The Initial Eighteen Months' Experience With Airline Pilots' Electrocardiograms.

JAMES H. BRITTON, M.D., HUGH G. WHITEHEAD, JR., M.D., THOMAS F. O'CONNOR, M.D. and IRWIN H. ARDAM, M.D., Federal Aviation Agency, Washington, D. C.

A review will be made of approximately 20,000 electrocardiograms presenting the breakdown of the types of abnormalities encountered and their significance. This group will be different from last year's in that approximately half of them will have had a previous electrocardiogram. Our inferences and conclusions will be presented. A report will be made on the electrographic findings of those pilots who have in the last year been involved in fatal accidents and have had a postmortem examination showing acute or severe coronary disease.

Pressure Caudal Injection and Back Manipulation.

J. HAROLD BROWN, M.D., Seattle, Wash.

A simple conservative therapeutic procedure for relief of sciatica and lower extremity paresthesias having as their origin, the lumbar disc syndrome, is outlined. Special consideration is given to its ap-

plication in afflicted air and ground crew personnel, with emphasis on more prompt return to duty and consequent man-hour conservation, than with other conservative measures such as bedrest, traction, etc., and prior to myelographic investigation and surgical intervention. The therapeutic concepts of the procedure are discussed, together with a review of the anatomy of the caudal canal. The procedure is described, being done on a hospital out-patient basis. Following the administration of a caudal anesthetic, with the patient awake and talking, a "tailored" amount of sterile saline and a potent corticosteroid are injected into the caudal canal, this being followed by back manipulation. Seventy-six cases upon whom over two hundred such procedures have been done over a five-year period, are reported with no complications. Excellent or good results were obtained in eighty-five per cent of those treated, relief of sciatica and low back pain being the criteria used. Rehabilitation in prompt return to work was accomplished more rapidly than by other conservative measures and certainly more promptly than following surgical interference. It is felt that surgical intervention in the majority of these cases was avoided. Colored slides are shown demonstrating the technique.

Physiological Support of Extreme High Altitude Flying Program.

CAPT. ROBERT J. BRUNEAU, USAF (MC), Laughlin AFB, Texas.

The paper presents a concept of providing total, integrated support of the crew member insuring that properly maintained and inspected protective equipment is correctly mated with a physically fit and mentally alert flyer. Medical and personal equipment problems in U-2 flights covering a three-year period are discussed. Results show the efforts of supervision, trend study, constant training, and standardization.

An Epidemiological Survey of Civil Airman Medical Records.

PAUL T. BRUYERE, M.D., Federal Aviation Agency, Washington, D. C.

The FAA and its predecessor agencies have required periodic physical examination of civil airmen since 1928. In spite of inconsistencies, losses and other discrepancies the records of these examinations are a potentially rich source of epidemiological information about the flying public which has been essentially untapped. Some two million records are being statistically processed to permit extraction and analysis of the data. Some preliminary results will be presented.

The Measurement of Operator Efficiency.

NEAL M. BURNS, PH.D. and THOMAS D. HANNA, B.S., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

The techniques of physiological monitoring and of psychomotor testing can combine to yield an overall estimate of operator efficiency. The simultaneous recording of performance and physiological response patterns was used in a number of test situations in order to determine the effect on performance efficiency of several stress conditions. The physiological measures (EKG, EEG, GSR, blood pressure, body temperature) are described and their usefulness assessed. In a similar fashion, those parameters of performance which underly a number of aircraft operator functions are also analyzed. A brief literature review and some suggestions for further research are offered.

Eye Movements and the Optogyral Illusion.

G. H. BYFORD, RAF Institute of Aviation Medicine, Farnborough, England.

The optogyral illusion has been the subject of considerable interest in both clinical and aviation medical spheres. There is a diversity of opinion on the role which nystagmic movements of the eyes play in this phenomenon; some maintaining that the illusion results from the passage of images across the retina during nystagmus and others that these movements of the eyes play no part in the production of the illusion. Experiments have been conducted with a view to establishing the existence or otherwise of a correlation between ocular nystagmus and the optogyral illusion. A vestibular stimulation was provided by a servo controlled rotating chair; the subject being rotated about a spinal axis in the normal seated position. Eye movements were measured by means of a contact lens and photoelectric cell, with a sensitivity of not less than 1 minute arc of eye rotation per cm. of trace deflexion. In addition, qualitative experiments were used to examine the illusion whilst an immovable image was maintained on the retina. No evidence was found which would support the hypothesis that nystagmic eye movements play any part in the production of the optogyral illusion. It is suggested that the eye movements, and sensations of rotation, are separate effects which stem from the same cause.

Bio-Engineering of an Anti-Suffocation Device.

LESTER CARLYLE, B.AE.E., Douglas Aircraft Company, Inc., El Segunda, Calif.

Introduction of closed breathing systems in certain U. S. Navy aircraft has revealed the need for a means to prevent suffocation following depletion of the oxygen supply. Such a device must be designed to open automatically following oxygen depletion, thereby venting the otherwise closed breathing system to ambient. Ideally, the cracking pressure of the device must be within the breathing capability of an unconscious person, yet above the awareness threshold of a conscious, but highly distracted pilot. Tests were first conducted at the Los Angeles County Hospital to determine the respiratory abilities of persons unconscious from anesthesia. Specifically, maximum

inhalation pressures manifested under conditions of complete respiratory obstruction were recorded and analyzed. A second series of tests is planned to determine the awareness levels of conscious, but highly distracted, jet pilots operating a flight simulator. The results of these two programs will be compared to provide the physiological specification for an anti-suffocation device.

Human Psychomotor Performance During Prolonged Vertical Vibration.

A. D. CATTERSON, M.D., G. N. HOOVER, PH.D. and W. F. ASHE, M.D., Ohio State University, Columbus, Ohio.

In a pilot study of human performance under vibration, Fraser, Hoover, and Ashe found that the ability of subjects to accomplish a tracking task while subject, tracking equipment, and visual display all vibrate is affected by frequency, amplitude, and plane of vibration. To further study this effect of vibration on performance, volunteer subjects were exposed to vibration in the vertical plane for twenty minutes at each of six selected frequencies from 2 cps through 15 cps, and at two amplitudes, 0.06 in. and 0.12 in. The subjects used a control stick to center a moving light on a square panel display for two five-minute periods near the beginning and end of each twenty-minute vibration exposure. Error was electronically summed with respect to time. Each subject served as his own control, and a learing curve was obtained for him during his successive experiences with the task. Results were statistically analyzed and revealed changes in performance relating to frequency, amplitude, and time duration of vibration.

Changes in Performance Proficiency Under Conditions Simulated by Water Immersion and Centrifugation.

RANDALL M. CHAMBERS, PH.D., DONALD A. MORWAY, B.S., CAPT. EDW. L. BECKMAN, MC, USN and CAPT. VICTOR G. BENSEN, MC, USN, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

An attempt was made to investigate changes in piloting proficiency and related human performance under gravitational conditions simulated by water immersion and centrifugation. Seven dimensions of human ability felt to best reflect the influence of these gravitational environments were studied: (1) tracking, (2) G-tolerance, (3) target aiming, (4) positioning, (5) complex discrimination-reaction time, (6) complex coordination, and (7) time estimation. Two separate experiments, a neck level immersion and complete immersion experiment, were performed each using six male subjects immersed for periods up to twelve hours. Before and after reduced gravity simulation in a water tank, the subjects were exposed to an 8 G re-entry profile produced by a human centrifuge. Changes in piloting skill level and in related performance capabilities were found.

Heavy Ion and Millibeam Irradiations on Mammalian Tissue.

HERMAN B. CHASE, Ph.D., Brown University, Providence, R. I.

Comparing 10 MeV/nucleon carbon ions from the Berkeley HILAC with x-ray effects in relation to the hair greying response for follicles short and resting at the time of treatment, there is a lower threshold per rad and a greater effect for carbon. When hair follicles are growing at the time of treatment and consequently the carbon range in tissue does not include the hair bulb, there is no greying effect for the first subsequent hair generation, but there is a pronounced effect on the second hair generation. This delayed effect indicates that damage in the upper follicle is later translated into pigment cell damage. Oxygen and neon ions even shorter in range also cause the delayed effect. With millibeams in the 200-micron range, there is a prevention of skin ulceration even at massive doses and some reduction in the greying and hyperplastic responses. When this beam is in the form of a slit and particularly when the radiation source is collimated 1.5 MeV electrons, the slit which parallels and exposes the 30-degree angle hair follicle produces a greying effect twice that of a slit at right angles. This effect again indicates the importance of the whole follicle, not only the immediate pigment producing area. In contrast to the protection afforded by non-irradiated tissue close to the millibeam, there is also an effect of irradiated tissue on non-irradiated areas, as within the follicle. These studies are related to the possible tissue effects from cosmic ray heavy primaries.

The Effect of Putrefaction on Carboxyhemoglobin Saturation of Various Body Tissues.

CAPT. HERBERT E. CHRISTENSEN, MSC, USA, LEO R. GOLDBAUM, PH.D, COL. FRANK M. TOWNSEND, USAF (MC), Armed Forces Institute of Pathology, Washington, D. C.

Conditions for the putrefaction of the various biological tissues have been examined for their effect on the carboxyhemoglobin concentration. The per cent carbon monoxide saturation of the putrefied tissues as determined by gas chromatographic procedure has been found to rise. This increase results both from the reduction of the carbon monoxide capacity as well as an increase in the carbon monoxide content of the tissue extract. The effects of environmental temperature of the presence or absence of environmental oxygen and carbon monoxide in the tissue extract have been explored. Several methods for determining the degree of putrefaction have been studied. Correlation between the artificial putrefactive conditions produced in the laboratory and the conditions found under natural circumstances has been attempted.

Four-Year Summary of an Executive Physical Program.

CAPT. SAMUEL P. CHUNN, USAF (MC), Resident, Aviation Medicine, Hq. AMC, Wright-Patterson AFB, Ohio.

This summary of 293 executive physical examinations conducted over a period of four years at Wright-Patterson Air Force Base, Ohio, details the studies accomplished during the examination and the findings. This group varied in age from thirty-seven to seventy-three years of age and represented a highly selected group of people. An attempt is made to estimate the cost of this examination as contrasted to the routine annual flying physical examination and to enumerate the various positive physical findings. A survey of TEFA values and serum lipoproteins on 120 of these examinations is presented in an attempt to grossly correlate these with such factors as age, weight, and other possible factors.

Human Acceleration Tolerance While Breathing 100 Per Cent Oxygen at 5 psia Pressure.

CARL C. CLARK, PH.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa. and CAPT. WILLIAM AUGERSON, MC, USA, National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

Low pressure gas provides less support against collapse of the chest under acceleration than atmospheric pressure gas. When breathing pure oxygen, the collapsed lung structures may not reinflate as rapidly after acceleration. Preliminary low pressure studies indicate individual variations in response to $+G_x$ or $+G_x$ tumbling to $-G_x$ acceleration, ranging from severe chest pain, to temporary post-run dyspnea, to no unusual sensations but with minor atelectasis detectable by x-rays or moderate temporary post-run vital capacity reduction, to no detectable responses. Injury may be more severe at lower G for longer duration, with respiration, than at higher G for shorter durations, with straining, including the valsalva maneuver with an inflated chest above $+8G_x$. With training in the breathing and straining procedure, no subject was incapacitated by acceleration at low pressure.

The Effect of Certain Variations in Physiologic State on Tolerance to Explosive Decompression.

LT. COMDR. PERRY CLOSE, MSC, USN and COMDR. ROGER IRELAND, MC, USN, USN School of Aviation Medicine, Pensacola, Fla.

Albino rats have been explosively decompressed under a variety of circumstances and the effect on survival and pathology noted. It was found that tolerance to explosive decompression was altered by posture, taping of the abdomen, the application of differential pressures between the head and thoracoabdomen, alterations in airway resistance (including tracheotomy) and other changes. The interpretation of these changes in relation to the cause of damage in explosive decompression has been considered.

Problems in Air Traffic Management: II. Prediction of Success in Air Traffic Controller School.

BART B. COBB, M.S., FAA Civil Aeromedical Research Institute, Oklahoma City, Okla.

Multiple regression techniques were employed to determine the efficiency with which measures derived from an extensive psychological test battery could be used to predict various performance criteria for trainees currently in Air Traffic Controller School. Training school criteria consist not only of success or failure for the course, but also academic averages and performance ratings in the training laboratories. Results and recommendations are compared with those of a previous experimental study which included some of the same psychological variables.

Effects of Positive G on Chimpanzees Immersed in Water.

LT. COMDR. KENNETH R. COBURN, MSC, USN, CAPT. PETER H. CRAIG, USAF (VC) and CAPT. ED. L. BECKMAN, MC, USN, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

This report deals with the physiological responses of fourteen experimental and three control chimpanzees exposed to increased G loading ranging from five to thirty-one positive G while immersed in water. Three general physical configurations of the G capsule were utilized in an attempt to determine the degree of protection offered. Arterial, venous, esophageal and endotracheal pressures were measured continuously, as were the internal capsule pressures. The physiological responses and the pathological changes observed are discussed in relation to the physical parameters used in this experiment. From the data it would appear that experimental procedure utilized produces overpressures in the pulmonary system of sufficient magnitude to cause loss of lung tissue integrity with the subsequent production of mediastinal emphysema and, further, that exposure to increased G under the experimental conditions utilized produces hydrostatic pressure gradients which favor the migration of air bubbles from the region of the mediastinum towards the head.

Evaluation of Pressure Garments for High Performance Aircraft.

THOMAS J. COOK and GEORGE E. HANFF, Lockheed Aircraft Corporation, Burbank, Calif.

A number of studies were performed to evaluate various pressure garments for use in high performance aircraft. Five American and foreign pressure garments were studied using various helmet/mask combinations and different aircraft and seat-mounted equipment. The tests were conducted in chamber facilities of Lockheed, North American, and the U. S. Naval Air Station, San Diego, using dummies and human subjects. Various flight profiles, including decompressions through 72,000 feet using wide-range physiological and suit instrumentation, were run and

data recorded. The American garments were found to provide mission completion through the time and altitude ranges studied. Using pressure helmets, British and Canadian suits demonstrated adequate short-term protection to altitudes of 71,000 feet and mission completion at 50,000 feet. However, with pressure demand masks, leakage was sufficient to question their use above 45,000 feet.

Injuries During Ejection Seat Training. CAPT. KENNETH H. COOPER, USAF (MC) and MAJ. FRITZ M. G. HOLMSTROM, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

The USAF ejection seat trainer used for emergency escape familiarization is an occasional cause of injury to trainees. Injuries that occur are usually minor and related to high headward acceleration of very short duration. Three new cases of coccygeal injury resulting from ejection seat training are reported. The character and magnitude of the accelerative forces, the role of body position, and the protective value of high energy absorbent seat cushions are discussed. Recommendations to minimize the recurrence of such injuries are included.

Internalized Animal Telemetry System—Engineering Considerations. WILFRED N. COOPER, B.S. and MERLE A. BEAUPRE, B.S.E., North American Aviation, Inc., Los Angeles, Calif.

This paper describes the engineering development of an improved method of gathering biomedical data. A biological telemetry system was implanted within an animal and subsequently tested under simulated missile conditions. The biological and physical environments are discussed. Engineering aspects of the surgery performed to implant a transmitter and sensing electrodes into two simians is presented. A description is given of an animal support system which includes methods of restraint, couch configuration, protective qualities, and hardware integral with the couch. Formulation of test specifications, amount and type of test performed, and the equipment used, are discussed. Data recorded and the comparative results of these data are described.

Some New Neurophysiologic Studies on Motion Sickness and its Therapy. R. L. CRAMER, PH.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

This study is concerned with determining the locus of effect of various anti-motion sickness drugs. Although a number of currently available preparations have demonstrable prophylactive effects against motion sickness, little is known of the locus of their effect in the systems mediating autonomic responses to vestibular stimulation. If the vestibular nerve and nuclei are affected, then intravenous administration of these drugs should modify the responses of single cells in the vestibular nuclei to standard electrical stimulation of the Eighth Nerve in decerebrate and decerebellate cat. Positive results will indicate that administration of these drugs to flying personnel must be considered carefully from the point of view of effects on other vestibular responses, including spatial disorientation.

Electrical Analog Simulation of Temperature Regulation in Man. R. J. CROSBIE, M.A., R. A. HALL, B.S. and J. D. HARDY, PH.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Using the basic equations for heat balance which have been developed to take into account heat losses by radiation, convection and evaporation, an electrical analog has been constructed to simulate the physiological responses to heat and cold in the nude man. As has been previously shown, physiologic temperature regulation involves three of the basic types of control modes, namely, proportional control, rate control and some of the characteristics of on-off control. The rate and proportionality constants have been determined experimentally on the assumption that the regulated temperature is the average body temperature (average body temperature = 80 per cent rectal temperature + 20 per cent skin temperature). Time constants for the various thermal changes can be determined from the thermal constants of tissue and the response times of the physiological variables of sweating, vasomotor activity and change in metabolic rate. The simulator predicts steady state situations of rectal temperature, skin temperature, metabolic rate, vasomotor state and evaporative heat loss under both resting conditions and exercise. Dynamic responses to sudden shifts in environmental temperature, air velocity, relative humidity and metabolic rate can be simulated to a considerable extent using equations based on the controls outlined above.

Early Ocular Effects of High Energy Proton and Alpha Radiation. MAJ. JAMES F. CULVER, and CAPT. NORRIS L. NEWTON, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Ocular tissue changes from ionizing radiation at relatively low energy levels is well documented. Alpha particles and protons at energy levels ordinarily encountered have not been considered as serious offenders. However, exposure to such particles at high energy levels may be encountered in space flight, and both early and delayed ocular effects can occur. Recent access to the 184-inch synchrocyclotron at the University of California at Berkeley has given us the opportunity to study the effects of proton and alpha particles at higher energy levels. One of the earliest responses is the presence of cells in the anterior chamber (iridocyclitis). Early ocular effects will be discussed and correlated with visual acuity studies on the Rhesus primates.

Genetic Studies in the Lower Radiation Belt.

A. GIB DEBUSK, PH.D., Florida State University, Tallahassee, Fla.

Living cells were exposed to flight conditions aboard the NERV capsule which penetrated to an altitude of 1,180 miles and remained in the lower Van Allen radiation belt for twenty-six minutes. Recovery was made and the cells have been examined for genetic damage. Preliminary results indicate a significant increase in mutation above the spontaneous level observed in three sets of controls. A further observation of non-genetic damage which appears to involve the growth mechanism will be discussed. The implications and relationships of both observations to possible hazards of manned space flight will be considered. All studies were carried out with the organism *Neurospora crassa.* Techniques for assay of genetic and physiological damage will be described.

Biological Effects of Heavy Ions.

R. A. DEERING and FRANKLIN HUTCHINSON, Yale University, New Haven, Conn.

The heavy ion linear accelerator (HILAC) available at Yale University makes it possible to study the biological effects of ions of elements between helium and argon and of energy 10 Mev/nucleon. The results of the following kinds of studies on biological materials will be presented: inactivation studies on dried enzymes; inhibition of various stages of hatching of Artemia eggs; killing, induction of mutation, and physiological studies on bacterial cells; effects on yeast cells of different ploidies; heavy ion effects on mammalian cells in tissue culture; and, effects of heavy ions in producing chromosome aberrations.

Early Detection of Glaucoma in Aging Aircrew Personnel.

STANLEY DIAMOND, M.D., Pan American World Airways, Overseas Division, San Francisco, California.

Glaucoma occurs predominately beyond the third decade, and will become an increasing hazard of the future in our aging aircrew personnel. It is extremely insidious in onset, and a high index of suspicion is necessary for early discovery. To be of practical value in aviation, the diagnosis must be established before irreversible field defects occur or before visual efficiency is adversely affected. This means early detection must be the task of alert medical examiners. Early warning symptoms or signs should lead to a test of the ocular pressure, and if found to be suspiciously elevated or abnormal, further evaluation is indicated to establish the diagnosis. Early subtle prodromal warning symptoms of chronic glaucoma include ocular pain, headache, haloes (rainbow rings around lights), subnormal accommodative amplitude as reflected by premature or early presbyopia, and decreased dark adaptation or disturbed night vision. Any of these symptoms should direct attention to the ocular pressure. A borderline or pathologic intraocular tension is the most important early sign and may exist long before the onset of visual field loss. The medical examiner should be familiar with the diagnostic criteria of early glaucoma. Tests which establish early diagnosis pertain to the following: 1.) Normal versus pathological intraocular tension levels (tonometry); 2.) Excessive rise of pressure on provocation (provocative tests); 3.) Measurement of the facility of aqueous outflow from the anterior chamber (tonography); and 4.) Anterior chamber angle examination (gonioscopy). Early diagnosis and prophylaxis is necessary to prevent the catastrophe of acute disabling glaucomatous attacks under flying conditions. Two cases illustrating early diagnosis are reported. It is emphasized that glaucoma can be detected and diagnosed early, and suspicious or potential cases may be ferreted out and placed under closer scrutiny. Successful case finding and control of glaucoma requires constant awareness and a high index of suspicion on the part of examining physicians.

Effects of High Acceleration on Rats.

LIEUT. KENNETH H. DICKERSON, MSC, USN and GEORGE H. KYDD, Ph.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Interest in recovery of biological payloads from ballistic probes and orbital satellites has created a need for information on the effects of re-entry accelerations on animals. Some of the forces involved lie in the range between 50 and 100 G and are of short duration. Studies have been conducted in which rats were subjected to a selected range of high accelerations for short time intervals. The results indicate that where the criterion for a successful test is survival without gross pathology, rats can survive these forces.

Factors Influencing Postmortem Level of Brain Lactic Acid in the Determination of Hypoxia.

CAPT. ABEL M. DOMINGUEZ, USAF (MSC), LEO R. GOLDBAUM, Ph.D., MAJ. JAMES R. HALSTEAD, USAF (VC) and COL. FRANK M. TOWNSEND, USAF (MC), Armed Forces Institute of Pathology, Washington, D. C.

The concentration of lactic acid in the postmortem brain has been employed experimentally as an aid in determining antemortem hypoxia in aircraft accident fatalities, both in this country and Canada. In the interpretation of brain lactic acid results, it has been reported that hyperglycemia is an important factor influencing the increased brain lactic acid in animals exposed to hypoxia prior to death. In addition it has been suggested that another factor, influencing postmortem lactic acid formation, is the oxygen tension within the brain. It was the purpose of this study to explore the influence of this factor on the postmortem level of brain lactic acid.

Human Physiological Data Telemetering System.

DAVID W. DOUGLAS, HERBERT R. SEAL and LT. COL. DAVID D. SIMONS, USAF (MC), Spacelabs,

Inc., Van Nuys, Calif., and School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

An improved method of physiological data transmission is described. A six channel FM/FM telemetry system is used to transmit data from a transmitter and power supply contained in a lightweight skin tight vest. Data are received and decoded by conventional means. Unique features of the system are small size and lightweight (41 ounces including transmitter, power supply, and vest). The paper describes the hardware and test conditions under which equipment has been used.

Internalized Animal Telemetry System—Electronic Considerations.

DAVID W. DOUGLAS, A.B. and HERBERT R. SEAL, Spacelabs, Inc., Van Nuys, Calif.

A single-channel biological telemetry system is described, in which a miniature solid-state transmitter is surgically implanted permanently in experimental animals, its carrier being modulated by physiological information and transmitted through the intact skin to a remote receiver and demodulator, where the physiological data are then recorded. Discussed are such problems as RF propagation through electrolytes which are at circuit ground, recharging a surgically implanted battery by use of an external low frequency RF field, and obtaining high modulation sensitivity with optimum stability. Also discussed are the relative merits of various telemetry techniques when applied to physiological monitoring of this type and the problems associated with multiple data transmission.

The Use of Over-Compression in the Treatment of Decompression Sickness.

COL. VINCENT M. DOWNEY, USAF (MC), Office of the Surgeon, Hq., Tactical Air Command, Langley AFB, Va.

All of the current accepted treatments for decompression sickness are essentially symptomatic. If we accept the cause of decompression sickness as nitrogen in the gaseous state which has evolved from solution in tissues, then it is logical to attempt to reduce the size of the nitrogen bubbles or force the gas back into solution. The author suggests immediate recompression of the patient in a tank to ambient atmospheric pressures equivalent to several atmospheres. This treatment has long been used in divers' "bends." The use in aviators was originally proposed by Behnke in 1942. To date, only one patient with aviator's "bends" has been treated by this method.

Immediate Auditory Retrieval of N Verbal Units from a 2N Ensemble.

J. J. DREHER, Ph.D., W. E. EVANS, M.A. and D. C. RASKIN, M.A., Lockheed Aircraft Corporation, Burbank, Calif.

A simple model of information recognition involving common and rare English words, short phrases, and foreign words is experimentally tested to isolate contributive effects of ensemble size, linguistic frequency, and meaning. These results are compared to those obtained by visual presentation of material.

Convulsive Syncope Induced by the Valsalva Maneuver in Subjects Exhibiting Low G-Tolerance.

CAPT. ROGER C. DUVOISIN, MAJ. FRANCIS KRUSE, JR. and CAPT. DONALD SAUNDERS, USAF (MC), USAF Hospital, Lackland, USAF Aerospace Medical Center, Lackland AFB, Texas.

The authors studied a group of patients who, by voluntarily performing a Valsalva maneuver, could reproduce episodes presenting the EEG and clinical features observed by Gastaut in convulsive syncope due to cardiac asystole. The group included two student pilots referred because of "convulsions" occurring in flight under positive G-stress. Their case histories are presented to demonstrate a mechanism of syncope important to aviation medicine and to illustrate the differentiation of convulsive syncope from epilepsy.

Education in the Aerospace Age.

COL. HAROLD V. ELLINGSON, USAF (MC), Gunter AFB, Ala.

Rapid changes in technology have necessitated frequent revisions of educational programs in support of aerospace operations. In the field of aerospace medicine, new courses have been developed by both civilian and military agencies, and existing courses have been modified to incorporate new material. Requirements for certification in aviation medicine by the American Board of Preventive Medicine are being studied by a committee, and revisions will be presented at a forthcoming meeting of the Board. Principal courses and programs in aerospace medicine, available at civilian and military institutions, are reviewed.

Turbine Transport Oxygen Requirements.

F. D. ENFIELD, B.S. and G. E. HANFF, B.S., Lockheed Aircraft Corporation, Burbank, Calif.

Civil Air Regulations concerning oxygen are somewhat difficult to correlate and to translate into engineering parameters useful to the designer. Tabular summaries of these requirements are given to aid in correlation. Charts are presented to help translate physiological requirements into oxygen quantity. Problems and methods of determining oxygen mask effectiveness in conveying tank oxygen into the human consumer are outlined. Current programs to provide equipment, techniques, procedures and regulations to meet physiological needs of passengers and crew at present and proposed turbine transport altitudes are summarized. The intent is to provide oxygen equipment design engineers with useful tools for assuring that physiological needs of the human occupants of turbine transports are met even under emergency conditions and assuring compliance with regulations.

On the Reliability of the Electroretinogram as a Response to Light Stimulus.

A. M. Ercoles, M.D. and L. Ronchi, M.D., Istituto Nazionale di Ottica, Arcetri-Firenze, Italy.

The use of the ERG as a diagnostic mean is criticized in view of the fact that unknown factors may affect the electrical response of the eye in a relevant manner. A number of paradoxical responses are reported and discussed.

Effects of Loud Brief Noise on Operant Behavior.

W. E. Evans, M.A., J. J. Dreher, Ph.D. and D. C. Raskin, M.A., Lockheed Aircraft Corporation, Burbank, Calif.

The effects of loud, brief, unexpected noise on immediate memory span and upon an information retrieval and programming tasks are experimentally investigated. Performance, GSR, and pre-test and post-test measures of blood pressure for noise-no-noise conditions are compared.

Aeromedical Support of the Tactical Air Force.

Lt. Col. Richard M. Fenno, USAF (MC), Sewart AFB, Tenn.

Aeromedical support of the Tactical Air Force has as its main problem the conditioning of aircrews for longe range flight. This has been a subject of concern to the USAF since the time aircraft were built which could stay aloft for periods in excess of eight hours. The aircrew conditioning program developed in the Tactical Air Command is described. The broad principles of aircrew conditioning are applicable to any flight, civilian or military, where factors of crew comfort, fatigue, in-flight feeding and mental and physical alertness can affect aircrew performance.

Automatic Precision Scale for Measuring Subject Weight in an Environmental Test Chamber.

J. Ferro, B.S. and B. Johnson, M.S., American Machine and Foundry Company, Niles, Ill.

One of the physical characteristics on which information is desired on human subjects undergoing tests in environmental test chambers is the subjects' weight. This paper describes an automatic precision scale which was designed for the Aeromedical Laboratory at Wright Field for use with their newest environmental test chamber. The scale requirements are unique in that the weight platform must be situated inside the chamber, with its wide range of environmental conditions, while the rest of the scale is located outside. The scale described incorporates a unique hydrostatic seal in isolating the two environments. The seal has a friction level far below the threshold of the scale. A system is also provided for automatically balancing the scale by varying the length of chains suspended on the load pan end. Continuous digital display and printing of the weight changes as a function of time are also provided. The entire scale is accurate to better than 5 grams.

Observations in the SAM Two-Man Space Cabin Simulator IV. Behavioral Factors in Selection and Performance.

Lt. Col. Don E. Flinn, Capt. John T. Monroe, Jr., USAF (MC), 1st Lt. Douglas H. Hagen, USAF (MSC) and Capt. Earl H. Cramer, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

The information gathered to date in the School of Aviation Medicine Two-Man Space Cabin Simulator will be presented from the viewpoint of the behavioral factors that influence the selection and performance of crew members in this environment. The impact of these behavioral factors on the structure of the crew and the mission profile will also be discussed. Comparison will be made between the results of this series of experiments and data obtained previously in the one-man space cabin simulator.

Human Orientations.

Gr. Comdr. W. R. Franks (RCAF Reserve), RCAF Institute of Aviation Medicine, Toronto, Canada.

Orientation may be defined as knowing how, when and where you are. Pertinent information is supplied by *all* the senses and normally is integrated to provide a conscious state. Accuracy of this will depend on (a) the validity of the information supplied by the senses; (b) the efficiency of the integration process. Information supplied by special senses can be subject to error due to inherent limitations, principally, (a) Events below a given threshold are not sensed; (b) Qualitative errors can arise due to the operation of Weber's Law. In addition, false integration can normally take place as in coriolis accelerations, altered visual perceptions, etc. Changed physiological states resulting from hypoxia, hyperventilation, positive acceleration, etc., can further alter the normal integration process. Finally, disorientation can itself be disorientating in a feed-back system. To educate lay operators to exploit the capacities and limits of this vital system, it is essential that Aviation Medicine assess the physiology involved.

Audition and Radio Frequency Energy.

Allan H. Frey, G.E. Advanced Electronics Center, Cornell University, Ithaca, N. Y.

A considerable amount of radio frequency energy is being propagated in the vicinity of airfields and aircraft carriers and will probably be propagated in ever increasing amounts. There is also RF energy in space about which relatively little is yet known, particularly that below 20 megacycles in frequency. Although the RF energy in the vicinity of airfields and carriers is carefully controlled to maintain it below the level at which it presents a biological hazard, there are transient effects which occur at biologically safe levels. This paper reports on one of these effects, the hearing of modulated RF energy without an external receiver. Apparently, harmonics of the pulse repetition rate, of RF energy with certain parameters, can

be discriminated by the human auditory system. The findings on normal and various types of deaf subjects under various conditions will be reported.

Oxygen Consumption During Human Vibration Exposure.

JOHN V. GAEUMAN, M.D., GEORGE N. HOOVER, Ph.D. and WILLIAM F. ASHE, M.D., Ohio State University, Columbus, Ohio.

Human subjects were exposed to whole body vibration at varying amplitudes and frequencies. They were seated unrestrained on a shake-table and free to assume the most tolerable posture which would also permit them to periodically carry out a fairly difficult tracking task. Oxygen consumption, carbon-dioxide elimination, and respiratory volume were measured and compared to resting controls in an attempt to estimate the amount of voluntary and involuntary protective muscular activity involved during vibration.

Biological Effect of Stress Following Ionizing Radiation.

JEROME J. GAMBINO, Ph.D., North American Aviation, Inc., Los Angeles, Calif.

There is evidence that animals surviving whole body or adrenal x-irradiation have an altered capacity to adjust to certain environmental stresses. It is hypothesized that disturbed adrenal functions may have a central role in this phenomenon, and may explain in part accelerated aging, reduced longevity and other observed delayed effects of irradiation. Data are presented which demonstrate in whole body and adrenal irradiated rats an altered response to standardized periods of intermittent cold stress. Implications of these data relating to the chronic exposure of men to damaging ionizing radiation during high altitude and space flights in nuclear powered craft are discussed.

Effect of Meteoroid Impacts into Pressurized Crew Compartments.

C. F. GELL, M.D., D.Sc. and A. B. THOMPSON, M.S.A.E., Vought Astronautics, Chance Vought Corporation, Dallas, Texas.

Frequency of occurrence and probability of penetration of space vehicles by damaging meteorites is discussed both as to theory and recent satellite test results. Penetration tests have been carried out at velocities up to 25,000 ft/sec of pressurized compartments containing various atmospheric and pure oxygen mixtures. Intense flash and oxidation phenomena has been recorded, which is accelerated with increased oxygen content in the cabin atmosphere. New additional hazards of flash heat, possible blindness, shock wave effects, and immediate depletion of cabin oxygen supply in addition to the previously anticipated decompression effects are discussed. Effects of various meteor bumper concepts are shown to reduce the hazard.

Diaphragm Movement Under Positive Acceleration.

FLT. LT. D. H. GLAISTER, RAF Institute of Aviation Medicine, Farnborough, England.

Movement of the diaphragm has been studied in man on the human centrifuge. A technique has been developed which allows direct recording of diaphragm movement at the oesophageal hiatus. Descent of the diaphragm has been demonstrated under positive acceleration and correlated with the degree of acceleration applied, and with simultaneous changes in lung volume and intra-abdominal pressure. The inflation of an anti-g suit raises the diaphragm; the net result of inflating the suit under positive acceleration is a reduced fall in diaphragm level. It is concluded that movement of the diaphragm at the oesophageal hiatus is similar to that at the dome, but that the excursion is about half that at the dome.

Viability Data Acquisition System for Testing Biosatellite Capsules.

E. S. GORDON and S. HORI, Armour Research Foundation, Chicago, Ill.

Under contract with the Air Force Missile Test Center, Holloman Air Force Base, a feasibility study and preliminary design have been completed for portions of a Viability Data Acquisition, Handling, Storage, Reduction, Display and Recall System (VIDAT System). The purpose of VIDAT is to test and evaluate biosatellite capsules and components, utilizing chimpanzees (and eventually humans) as test subjects. The variables initially considered were systolic and diastolic blood pressure, respiration rate and waveform, electrocardiogram, heart rate, rectal and skin temperatures, O_2 and CO_2 partial pressures within the capsule, total pressure, dry bulb temperature, and relative humidity. Among the unique requirements and restrictions were: two week continuous test period during which access to instrumentation within capsule is prohibited; chimpanzee only partially restrained, precluding instrumentation techniques and equipment subject to chimpanzee disruption; ease, simplicity and rapidity of transducer attachment to a struggling chimpanzee; applicability of the same transducers and attachment methods to humans; transduction by external means only (no subcutaneous electrodes or other implantations); analog outputs for all variables; reliability of 95 per cent over two week continuous operation. Instrumentation was devised or studied for physiological data acquisition: An experimental method for chimpanzee thigh blood pressure measurement was found despite failure of the Korotkow method at this location; the feasibility of a closed-hydraulic servo controlled pressure cuff featuring small size, simplicity, and ease of automatically programming pressure was determined; a new type of EKG electrode for long term continuous use was constructed and partially tested; a highly sensitive, simple respiration waveform transducer was tested and means for its utilization determined; concepts for a chimpanzee bioelectronic harness and transducer attachment methods were formulated. Fundamental problems of physiological reaction to physical instrumentation are discussed.

Changes in the Human Electroencephalograph (EEG) at a Simulated Altitude of 27,000 Feet.

LT. COMDR. J. J. GORDON, MC, USN, R. E. JENSEN, Ph.D., R. D. SQUIRES, M.D. and W. SIPPLE, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The occipital EEG and a performance task were recorded simultaneously on a magnetic tape for each of 10 subjects in the Aviation Medical Acceleration Laboratory altitude chamber. Subjects breathed 100 per cent oxygen until an equivalent altitude of 27,000 feet was attained; thereafter, the subject was switched to ambient air until a qualified observer decided to return the subject to 100 per cent oxygen. The subjects exhibited wide temporal variation in their ability to withstand altitude. The EEG data, however, exhibited a striking parallel relationship between the increase in amplitude of the filtered 5.5 c.p.s. frequency and the deterioration of the performance task.

Aeromedical Support in World War II.

MAJ. GEN. DAVID N. W. GRANT, (Ret.) USAF (MC), Former Surgeon General, United States Air Force, Washington, D. C.

Although direct support of the aircrewman by the flight surgeon started in World War I, it reached a new high in World War II. This gigantic effort called for ingenious action by physicians charged with the constant care of aircrews subjected to ever more stressful battle and environmental situations. The organization of an Air Surgeon's Office and the new emphasis on both the practice of aviation medicine at squadron level and the constant demand for new research and development efforts offered a great challenge to the World War II flight surgeon. The need for these "flight surgeons" was even questioned by some, and their role as advisors and confidants of the line commanders in all things aeromedical became solidified. Though necessarily based upon past history this paper attempts to lay a groundwork for the evolution of the modern aerospace medicine specialist from a first hand point of view.

Psychobiologic Effects of Hypodynamics Induced by Water Immersion.

CAPT. DUANE E. GRAVELINE, USAF (MC), BRUNO BALKE, M.D., CAPT. RICHARD E. MCKENZIE, USAF (MSC) and BRYCE HARTMAN, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Utilizing a technique involving whole body immersion in water, a hypodynamic environment was produced in which the normal weight sensations were removed and movement was effortless. This experiment was conducted with one subject for a 7-day period during which time extensive biologic data were collected. There are definite indications that pronounced functional impairment results from prolonged exposure to hypodynamic conditions. Following the period of immersion marked changes of cardiovascular reflexes and diminished muscular tone were apparent. Hematologic investigations and extensive biochemical studies on blood and urine show significant changes, and there is a gross disruption of psychomotor effectiveness. In general, this study suggests that during prolonged space flight under true weightless conditions the organism may attain a critical state of deconditioning which will seriously attenuate his tolerance for re-entry stresses and the normal gravitational environment.

Coriolis Acceleration Effects Associated with Movement of Humans by a Powered Gimbal System on a Human Centrifuge.

R. F. GRAY, M.A., R. J. CROSBIE, M.A., R. A. HALL, B.S., J. A. WEAVER, A.B. and C. C. CLARK, Ph.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Three subjects were exposed to rotation at 1.0 G or 3.0 G at the 50-foot radius of a centrifuge. These gave angular velocities of the centrifuge of .80 and 1.39 radians per second, respectively. Simultaneously each subject was rotated around an axis close to his body by means of a powered gimbal system. These secondary rotations (maneuvers) occurred around an axis parallel to the *radius* of the centrifuge (0°), almost parallel to the *axis* of the centrifuge (272°), or around an axis half way between these (325°). These maneuvers had angular velocities of (a) .3927 rad/sec, (b) .1964 rad/sec, (c) .0982 rad/sec, or (d) .0491 rad/sec. In general the subjects reported or failed to report visual coriolis illusions in accordance with predictions of torque generated in the semicircular canals by coriolis accelerations. Estimates of thresholds were obtained.

Estimation of the Horizontal or Vertical With Head Upright, on the Side, and Inverted Under Static Conditions and During Exposure to Centripetal Force.

CAPT. ASHTON GRAYBIEL, MC, USN and BRANT CLARK, Ph.D., USN School of Aviation Medicine, Pensacola, Fla.

The observations were carried out on five subjects. The task consisted of setting a luminous line in the dark: (1) before rotation, (2) when exposed to centripetal force resulting in a change in direction of force relative to the subject (angle θ 6° or 12°), and (3) after cessation of rotation. Seated upright, the estimations of the horizontal were quite accurate before and after rotation, while, during exposure to centripetal force, a correction was regularly made in accord with the change in angle θ (oculogravic illusion). Lying on the side or with head inverted, all subjects exhibited gross inaccuracies in setting the line under static conditions, and the oculogravic illusion could not be demonstrated.

Some Observations of the Effects of 100 Per Cent Oxygen and Positive Acceleration on R.A.F. Aircrew.

FLT. LT. I. D. GREEN and

COMDR. B. F. BURGESS, USN, MSC, RAF Institute of Aviation Medicine, Farnborough, England.

A set of symptoms experienced by aircrew following flights during which they have been subjected to high levels of positive acceleration whilst breathing 100 per cent oxygen has been recognized by the Royal Air Force for several years. The incidence of this syndrome amongst pilots is given. Radiographs of the chest taken after flight and the effects of the disorder upon lung volume are described. The significance of these effects is discussed together with the need for further experimentation and the form that this should take.

Coriolis Effects on Operator Movements in Rotating Vehicles.

CHARLES P. GREENING, Ph.D., Advanced Engineering Autonetics, North American Aviation, Inc., Downey, Calif.

Rotation of manned space vehicles has frequently been considered as a means of providing artificially some of the characteristics of a gravity field. The relatively high rates of rotation anticipated in moderate-sized vehicles will bring into prominence a class of phenomena known as Coriolis effects. In this paper, the magnitude and direction of the forces on the human body associated with Coriolis effects are studied analytically as a function of vehicle spin rates, bodily movement rates and the orientation of vehicle work areas. Relationships among the pertinent variables are expressed parametrically, and also discussed qualitatively. Some implications for work station arrangement are discussed.

Measurements of Eye Movements During Low-Frequency Vibration.

FLT. LT. J. C. GUIGNARD and A. IRVING, RAF Institute of Aviation Medicine, Farnborough, England.

Measurements have been made of the frequency-response of compensatory and pursuit eye movements during vertical sinusoidal vibration of: (a) the man, with the target at rest; and (b) the target, with the man at rest. In such measurements it is essential to use a method which in no way impedes movements of the eye. Such a method, in which, by corneal reflection, the image of a wedge-shaped object is viewed through a slit by a photomultiplier tube, is described in this paper. The vibration frequencies investigated ranged from 0.5 to 5 cycles per second. Angular displacement-amplitudes of the target with respect to the eye of up to 2° were used. The importance of normal vestibular function in determining the servo characteristics of the oculomotor system is discussed.

Aeromedical Aspects of Turbo-Jet Commercial Aircraft.

C. C. GULLETT, M.D., Trans World Airlines, Inc., Kansas City, Mo.

This paper reviews the inflight environment of present commercial turbo-jet transports. There is a brief discussion of radiation hazards at current operating altitudes. The reliability of the pressurization system demonstrated to date results from engineering design. Statistics are given on vibration environment of jet versus propeller driven aircraft and its effect on the human body. A comparison is made of climb and descent configurations and acceleration forces developed by various aircraft. The noise environment comparison is made of the interior and its relationship to crew fatigue. This study was made in relation to the evaluation of the question of physical effects of jet flying on cabin attendants. A statistical analysis was made of the physical findings of hostesses flying propeller driven aircraft. A comparative study was then conducted on 100 hostesses' physical findings before flying on jet aircraft with the findings on the next annual examination after flying on jet aircraft. The results of this study were quite revealing and dispelled the widely spread claim that jet flying *per se* caused menstrual disorders in hostesses. There were no statistically significant changes in physical findings or interval medical history.

Effects of Venous Impediment and Muscular Effort on Motor Performance.

THOMAS D. HANNA, B.S., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Because of the fatigue and decreased efficiency resulting from wearing various aviation protective gear on prolonged flights, the following study was conducted. Two measures of stress, (1) static muscular tension, and (2) brachial venous impediment were used to evaluate various aspects of motor performance. Two degrees of each of these two stress conditions were employed. The results show that manual dexterity is deleteriously affected by all stress conditions, while fine weight discrimination and rapidity of sustained finger movement were not so affected. A significant increase in heart rate was observed to accompany every stress condition.

The Effect of Static Air Pressure in the External Auditory Meatus on Hearing by Bone Conduction.

CAPT. RONALD G. HANSEN, USAF (MSC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

The specific purposes of this study were to determine the effects of various static air pressures in the external aduitory meatus on hearing acuity for air and for bone conducted sounds. Threshold measurements were obtained by the Method of Adjustment for continuous frequency change from 125 to 8000 cps at each of four pressure conditions up to 25 centimeters of water pressure. The resultant changes in air and bone threshold sensitivity will be described and discussed in terms of increasing the attenuation of ear protective devices and the possible aid of such tests in an otological diagnostic battery.

Sequence of Pathological Changes in the Rat Brain Following Exposure to Alpha Particles from the 60-Inch Cyclotron.

WEBB HAYMAKER, M.D., ALBERT BEHAR, M.D., IGOR KLATZO, M.D.

and CORNELIUS TOBIAS, Ph.D., Armed Forces Institute of Pathology, Washington, D. C., National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Md., and Donner Laboratories, University of California, Berkeley.

The earliest time intervals at which damage was observed in the brains of rats exposed to alpha particles (with energy of about 12 Mev per nucleon) at different surface dose levels (through a port 14.3 mm. in diameter) was as follows: 12,000 rad, 3 hours; at 6,000 rad, 6 hours; at 3,000 rad, 20 days; and at 1,500 rad, 7 months. Individual nerve cells and neuroglia were damaged initially, and then a zone of cellular damage, in a region corresponding to the Bragg peak, became evident across the cerebral and the cerebellar cortex. The width and depth of the zone, which were greater in the cerebrum than in the cerebellum, corresponded to the amount of energy given off along the course of the Bragg curve. At the 6,000 rad surface dose level, circulatory and permeability disturbances (as brought out by the Pickworth-Lapehne and fluorescein-labeled serum protein techniques, respectively) appeared some 40 hours after nerve cell and glia had been damaged, and at about the same time as the zone of cellular damage became established. The evidence thus indicated that nerve cell and glial damage was incurred initially and that circulatory change and increased vascular permeability subsequently contributed to the extent of the lesions.

Abrupt Acceleration of Human Subjects in the Semi-Supine Position.

ROBERT N. HEADLEY, M.D., JAMES W. BRINKLEY, B.S. and KENNETH K. KAISER, B.S., Aerospace Medical Division, Wright-Patterson AFB, Ohio.

One hundred and twenty experiments have been conducted to determine the salient biomechanics of human protection against the potentially fatal hazard of abrupt acceleration during aerospace flight. Twenty human subjects have been exposed to acceleration forces ($^{+}A_x$) of extremely short total duration, brief rise time, and magnitudes about fifty "g's." The acceleration profiles have been controlled by varying impact velocities and rate of attenuation. Numerous configurations of crushable paper and aluminum honeycomb have been utilized to attenuate velocities ranging up to 30 feet per second. Human volunteer subjects have been subjected to transverse impact in the semi-supine position using body support systems incorporating contoured, rigid, urethane couches and ureaformaldehyde sphere mattresses. This research effort has exposed new and unique problem areas and has led to development of new design criteria for protective body support and restraint systems.

Environmental Aspects of the B-70 MACH 3 Escape Capsule.

J. F. HEGENWALD, JR., B.S., North American Aviation, Inc., Los Angeles, Calif.

The aircrew emergency escape system of the B-70 air vehicle provides safe egress at performance levels as high as Mach 3.0 above 70,000 feet and as low as 90 knots at zero altitude. The capsule's influence upon normal and emergency flight operations is discussed. Oxygen and pressurization provisions, as well as crew positioning and restraint devices, are described. The acceleration environment through all escape phases is presented in conjunction with unique communications and survival features.

Precision of a Lever-Displacement Response of Rats Following Exposures to Positive G.

ROBERT M. HERRICK, Ph.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

For a lever-press to an interval between 23.6° and 28.8° of arc (21 min to 25.5 min of arc), rats received a reward. A press to any other distance, i.e., a press between 0° to 23.5° or between 28.9° to 44.0°, was not rewarded. Rats were well trained in this task. Then, this behavior was evaluated immediately following 3 minute exposure to positive G. G values ranged from 2 G to 20 G. Following exposure to the higher G levels, all lever-pressing behavior stopped temporarily, then resumed at a subnormal rate. Of the total number of presses made during a daily test period, the percentage (about 60 per cent) made to the "correct" interval was the same on the pre-g control days and on the g days.

Neurocirculatory Collapse Associated with Reduced Barometric Pressure.

CAPT. MAURICE E. HERRING, USAF (MC), LT. COL. STEPHEN J. RUDOLPH, JR., USAF (MC) and CAPT. DOMENIC A. VAVALA, USAF (MSC), 832nd Tactical Hospital, Cannon AFB, N. M.

Case presentation of a pilot who experienced symptoms of dysbarism while on flight at approximately 35 thousand feet without cabin pressurization. Previous preparation with 100 per cent oxygen had not been accomplished prior to take off, and symptoms began approximately 20 minutes after take off. Pilot demonstrated typical signs of dysbarism, including chokes and skin mottling. Discussion of the syndrome along with discussion of the method of management and treatment is presented.

Investigations to Determine Human Tolerance to Abrupt Acceleration in Capsule Systems.

GALEN A. HOLCOMB, Stanley Aviation Corporation, Aurora, Colo.

Landing impact effects are one of the major physiological problems of capsule systems in general, whether they be atmospheric or space vehicles. Published human tolerance allowables are basically unuseable when evaluating the accelerations produced by impact with the earth's surface, since the accelerations measured on a human subject, in most cases, are of shorter duration and higher rates-of-onset than the allowables describe. Approximately 150 human experiments were undertaken to determine tolerability. Sub-

jects were dropped on concrete, dirt and sand from heights ranging from 9'9" to 12'0" at drift velocities up to 23 mph, while strapped in a production type escape capsule. Accelerations up to 83 G's were recorded on the subject's sternum.

Physiological Instrumentation Systems for Measuring Pilot Response to Stress at High G and Zero G.

GEORGE R. HOLDEN, JOSEPH R. SMITH and CAPT. HARALD A. SMEDAL, MC, USN, NASA, Ames Research Center, Moffet Field, Calif.

An airborne physiological instrument system reported in NASA TN D-351 has been modified and additional tests have been made in the University of Southern California and AMAL centrifuges and in an F-104B airplane. These tests covered various levels of acceleration from zero to 8 g. The measurements made were, in part: ECG, blood pressure, pulse wave, respiration rate and volume, and carbon dioxide content of expired air. The data from a three-lead electrocardiograph were recorded, using a unique balanced transistor amplifier. Systolic and diastolic blood pressures were measured using an automatic sequencing occluding arm cuff and microphone stethoscope. Pulse wave on the wrist was obtained with a vasochromograph and a.c. amplifier. Several methods were used to measure respiration rate, and respiration volume was measured with a wedge spirometer. The expired air was analyzed for CO_2 content with a very much modified Bechman LB-1 gas analyzer. The quanitative effects of short term periods of zero g on pilot control performance were determined by measuring the tracking accuracy, the equivalent analytical transfer function, and the physiological condition of a subject in the rear seat of an F-104B airplane being flown in a 60-80 second zero-g trajectory. A tracking task played back from a tape recorder was presented to the subject on an oscilloscope. The subject used a sidearm controller to attempt to wipe out his tracking error. A small airborne analog computer computed the simulated airplane's response to the control motion and changed the tracking display accordingly. The experiment was repeated and thus affords a direct comparison with a study of pilot control behavior previously conducted on ground-based simulator and a centrifuge.

Audiometry: Measure of Recruitment in Hearing Losses of Flying Crews.

A. E. HUSTIN, M.D., Oto-rhino-laryngology Services, Sabena Airlines, Melsbrock, Belgium.

The author has studied recruitment using the method of von Bekesy in graphic continuous audiometry. He has endeavored in this way to distinguish the injuries of the cochlea from those of the higher centers. He was thus able to consider the degree of casualty attributable to noise traumatisms, barotraumatisms and other general causes in the etiology of these affections.

The Effect of Back Angle and Molded Support Upon Intra-Pulmonary Pressure During Forward ($+G_x$) Accelerations.

CAPT. ALVIN S. HYDE, USAF (MC), Aerospace Medical Division, Wright-Patterson AFB, Ohio.

Static intra-pulmonary pressures were recorded at accelerations from 2 to 16 G in live (curarized) and dead dogs and monkeys during forward inclinations of 5° increments from 0° to 45°. The pressures primarily reflect shifts of the diaphragm due to accelerator forces. The influence of staged evisceration and staged molded support systems were also studied. Essentially null displacement occurred between 10° and 15° of forward inclination. Above and below these angles diaphragmatic displacement was proportional to acceleration and relatively uninfluenced by molded support systems. Staged evisceration clearly established the literal dependency of diaphragmatic movement upon the presence of the liver.

Changes in the Human Electroencephalograph (EEG) During Positive Acceleration.

R. E. JENSEN, Ph.D., LT. COMDR. J. J. GORDON, MC, USN, R. D. SQUIRES, M.D. and W. SIPPLE, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The occipital EEG was recorded on magnetic tape during 75 centrifuge runs on fifteen human subjects while exposed to positive acceleration sufficient to produce blackout lasting from 2 to 22 seconds. A performance task and change in EEG electrode impedance were also recorded. Motion pictures were made of subject's face during runs. The EEG was separated into 18 continuously recorded component frequencies using sharply tuned filters. The data thus obtained showed increase in amplitude of beta frequencies so long as the subject was able to resist cerebral hypotension. As he failed to compensate there were varying degrees of shift toward increased amplitude in the lower frequencies. A marked beta-delta shift during acceleration with appearance of high amplitude delta and loss of beta indicated imminent loss of consciousness.

Sanitation and Today's Jet Airliner.

JOHN L. JOHANSON, B.S., Boeing Airplane Company, Seattle, Wash.

Jet propulsion is not the only different innovation on the new commercial airliners. Jet passengers not only travel faster to any part of the world, but they travel with the protection afforded by the latest in aircraft sanitation. Modern food galleys, improved dechlorination filters, nylon water lines, and recirculating flush toilets are recent developments. New techniques are also being applied to assure the purity of water and food, and the sanitary disposal of wastes.

This paper describes the evaluation and application of sanitary concepts during the design, production, and delivery to the airline customer. Many of these concepts also apply to current operation of the airliner.

The Use of Newly Designated Aviators as Instructors.

LIEUT. (jg) J. H. JOHNSON, MSC, USNR, and J. R. BERKSHIRE, M.A., USN School of Aviation Medicine, Pensacola, Fla.

Newly designated aviators are sometimes assigned as flight instructors because of personnel shortages. The wisdom of this policy has frequently been questioned. Research studies find no differences between fleet-experienced and first tour instructors, with respect to: (1) grades of students, (2) accidents, (3) attitudes of students toward instructors, and (4) motivation of students. However, results from fleet follow-up data indicate that pilots who first serve a tour of duty as instructors are not as effective in the fleet as are newly designated aviators.

Escape Systems of Current USAF Fighter Aircraft.

MAJ. LOUIS F. JOHNSON, JR., USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

The escape systems of current USAF fighter aircraft are considered in their component sections of initiators, catapults, seatbelt initiators, parachute timers and parachute types. These component sections are analyzed as to their sequential operation, operating characteristics and operating times. Time and altitude comparisons are made between two combinations of functional components to demonstrate how shorter time characteristics can be meaningfully transposed into altitude.

The Importance of the Otoliths in Disorientation.

W. H. JOHNSON, Ph.D., and N. B. G. TAYLOR, M.D., Ph.D., Defence Research Medical Laboratories, Toronto, Canada.

Other than the oculogravic illusion, little is known of the effects of stimulating the otoliths. It is possible, even probable, that the stimulation of these organs particularly during and subsequent to weightlessness, and during changes in linear acceleration, could produce effects of importance in flight. The lack of knowledge results mainly from the difficulty in the laboratory of stimulating the otoliths without at the same time stimulating the semicircular canals; there is also a scarcity of objective signs of otolithic stimulation. A new laboratory procedure will be described with the aid of moving pictures. Human subjects are exposed to "revolution without rotation," i.e., to a linear acceleration that is continuously changing direction clockwise or counterclockwise. Evidence will be presented that suggests this is an otolithic stimulus causing measureable effects.

Aeromedical Problems in Worldwide MATS Support.

COL. MAURICE B. JOHNSTON, USAF (MC), Military Air Transport Service, Scott AFB, Ill.

The mission of the Military Air Transport Service, the Nation's only strategic airlift force, is presented with emphasis on patients, passengers, cargoes and crews. The role of the Flight Surgeon in support of these functional areas, and the resultant aviation medicine program within the Military Air Transport Service, is highlighted to show that a transport organization has challenges in aviation medicine as do the tactical elements of our armed forces. Fatigue among transport pilots, which the literature reveals little in the way of research or studies, is discussed; recent results of transport crew fatigue studies conducted by the Military Air Transport Service and the USAF Aerospace Medical Center are cited. The deployment of an airlift force in strategic airlift exercises is outlined.

Anthropometry of U. S. Navy Pilots.

CAPT. WALTON L. JONES, MC, USN and EDMUND C. GIFFORD, B.A., USN Bureau of Medicine and Surgery, Washington, D. C., and Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

In order to provide an adequate source of morphological data on U. S. Navy pilots, an anthropometric program was conducted by the Bureau of Medicine and Surgery and the Bureau of Naval Weapons. One thousand one hundred and ninety Naval pilots were measured with respect to 25 different morphological features. The data from this study are presented in the form of correlation coefficients, percentiles, and frequency distributions. Also, a comparison of these data is made with other sources of anthropometric data revealing the existence of significant differences on certain morphological features between Naval pilots and other pilot population groups. The application of these data to the design of clothing and equipment is discussed.

Neurophysiological Mechanisms of the Oneiric Activity.

M. JOUVET, M.D. and D. MOUNIER, Ph.D., School of Medicine, Lyons, France.

Experimental results obtained during physiological sleep in normal human beings, in patients with brain lesions and in chronic cats with implanted electrodes lead to the following conclusions: (1) Dream occurs, in humans, during a peculiar stage of sleep which is the deepest (low voltage fast activity associated with fast ocular movements and cardiovascular changes). (2) A similar type of sleep is recorded periodically in chronic cats: fast cortical activity, augmentation of threshold of arousal, rapid eye movements, total disappearance of E.M.G. activity and cardiovascular changes. (3) Decortication in cats and human patients does not suppress the peripheral components of dream activity. (4) It is shown that this stage of sleep is

determined by the pontile reticular formation since it is possible to suppress electively this stage of sleep by pontile lesions in cats. (5) Oneiric activity thus appears to be a very important function which is supported by a periodical active pontile mechanism.

Skin Temperature Responses to Simulated Nuclear Flash.

CAPT. W. C. KAUFMAN, USAF, LT. H. T. DAVIS, USAF and MAJ. A. G. SWAN, USAF, Aerospace Medical Division, Wright-Patterson AFB, Ohio.

Skin temperatures and irradiance levels were measured on a subject seated in a tactical aircraft exposed to thermal radiation characteristic of nuclear weapons. Thermal energy was supplied by 1032 lamps at power levels up to 4000 kw. Standard flight clothing was worn. Cockpit airflow was less than 50 cfm at 70° F. Subject tolerance was attained in a 2.3 second pulse of 3.5 cal/cm^2 at canopy exterior and 1.5 cal/cm^2 at head level measured by calorimeter with 90° acceptance angle. This pulse charred paint on fuselage and headrest and seared the subject's glove. Bare forehead skin temperature reached 126° F. and insulated knee temperature reached 104° F. Subject feelings were of distinct pain. Physiological responses and heat transfer mechanisms in extreme thermal energy pulses are discussed.

The Passive Closed Respiratory System for Life Support in Aerospace Flight.

DONALD A. KEATING, B.M.E. and KONRAD WEISWURM, Aerospace Medical Division, Wright-Patterson AFB, Ohio.

As man ventures into outer space his needs must be supplied and carried within the sealed environment of the space ship. Regeneration of the sealed environment can be achieved by the "passive atmosphere-chemical reaction" by exposing relatively large areas of solid chemical to the sealed atmosphere and allowing mixing of the gaseous atmosphere with the chemical bed by natural diffusion. This process has been demonstrated in USAF Project Hermes (seven-day ground test), USAF Project Stargazer (high altitude balloon flight) and other prolonged duration sealed environment research involving human subjects. The effects of prolonged weightlessness upon the "atmosphere-chemical reaction" have been studied by the launch of a small closed respiratory test capsule into outer space utilizing the solid chemical potassium superoxide.

In-Flight Bio-Instrumentation in a Near-Space Operational Environment.

LT. COMDR. G. F. KELLY, MC, USN and C. G. PHIPPS, U. S. Naval Missile Center, Point Mugu, Calif.

To bring known methods of airborne physiological instrumentation to a point of usefulness in an operational environment requires close coordination between the medical profession, the electronics profession and operational aviation. This cooperation has been possible to a large degree within the framework of the Naval Missile Center. A versatile system of instrumenting pilots and radar operators of high performance aircraft for the electrocardiogram and electroencephalogram will be presented. Operational methods and techniques developed to instrument subjects in the Mark IV Full Pressure Suit and obtain data, which is used as a part of missile system evaluation, will be discussed. Records and results will be presented as well as applications of these methods to physiological instrumentation during space flight.

Aeromedical Support of the B-58 Operations.

CAPT. ROY J. KELLY, USAF (MC), USAF Hospital, Carswell AFB, Texas.

The designed performance of the B-58 places specific demands on the pilot. For successful man to machine matching, these demands concern human factors that must fall within physiologic limits. Human factors of greatest concern are determined by interviewing 25 pilots who are qualified in the B-58. The opinions of the pilots encompass human factors in areas of engineering, safety, and physiologic support systems. Information regarding the question of "How much automation and how much pilot performance" is presented. The various human factors are discussed and recommendations made.

A Comparison of Susceptibility to Symptoms in the Slow Rotating Room (Canal Sickness) and Motion Sickness in Flight Personnel.

ENS. R. S. KENNEDY, MSC, USNR and CAPT. ASHTON GRAYBIEL, MC, USN, USN School of Aviation Medicine, Pensacola, Fla.

Previous studies have shown that stimulating the semi-circular canals in healthy subjects (caused by movements of the head while slowly rotating in a small room) produces symptoms collectively termed "canal sickness." In this experiment susceptibility to canal sickness was measured in three groups of subjects (aviators who had completed military test pilot school, experienced aviators, and incoming flight students) and compared with their susceptibility to other forms of motion sickness and vertigo, as determined by interview and questionnaire. The findings are interpreted in terms of the validity of the test for canal sickness, as a predictor of motion sickness.

Development of a Water Recycling Device With Special Reference to Space Application.

J. J. KONIKOFF, B.S. and L. W. REYNOLDS, B.S., Missile and Space Vehicle Department, General Electric Company, Philadelphia, Pa.

The recovery of potable water from man's metabolic wastes is considered a necessity whenever long term manned space flight is contemplated. Several methods have been evaluated and a vacuum distilla-

tion followed by high temperature catalytic decomposition has been studied in this laboratory. A compact, high yield approach that lends itself to space application has been developed. Use of the vacuum distillation technique eliminates all but the most volatile impurities from the condensate, without decomposing solid metabolites and does not require application of external heat to the wastes. The high temperature catalysis destroys the volatile compounds in the water vapor. Heat necessary for the catalyst may be derived directly from solar radiation. The recovered water was tested in accordance with the U.S. Public Health Drinking Water Standards and adjudged potable. Further analysis for bacterial contamination indicated that no coliform organisms were present. A rat colony was maintained on this water for four months in order to determine whether chronic exposure produced any deleterious effects. Finally, a human subject subsisted entirely on "recovered" water for an entire week. Engineering studies have shown that the overall requirements for a one-man recovery apparatus is about 1/3 cubic foot. The gross weight of a one-man unit is estimated to be less than fifty pounds.

The Response of Normotensive Patients with Coronary Artery Disease to the Diuretic Methyclothiazide.

Louis R. Krasno, M.D. and George J. Kidera, M.D., United Air Lines, San Francisco, Calif. and Chicago, Ill.

It has been demonstrated that nitroglycerin decreases cardiac work by reducing peripheral resistance. It is believed that the effectiveness of nitroglycerin in angina pectoris is not due exclusively to coronary dilatation but also to the decreased cardiac work. Accordingly, the present study was initiated upon the assumption that an effective diuretic may reduce peripheral resistance and decrease cardiac work in normotensive patients with angina pectoris. It was also believed that the reduction in cardiac work would provide an improved physiological balance between the myocardial requirements and the existing coronary blood supply. A group of normotensive patients with angina pectoris who have been poorly controlled by nitrates, ataraxics and monamine oxidase inhibitors were selected for this study. The patients alternately received the diuretic methyclothiazide (Abbott) and placebo at three-week intervals. The active agent reduced the symptoms of angina and increased exercise tolerance significantly. With the placebo the symptoms and exercise tolerance returned to former levels. It is significant to note that the diuretic controlled and improved these patients, whereas previous medical regimes were ineffective. On the basis of these preliminary observations, this study has been extended to determine the frequency with which the "diuretic therapy" of normotensive patients with angina pectoris is effective in a large series. Observations are also being made on the effect of methyclothiazide on the abnormal electrocardiogram and ballistocardiogram in normotensive patients with previous myocardial infarctions and left ventricular hypertrophy. It would appear that the reduction of cardiac work may be desirable in those situations where the efficiency of the myocardium has been compromised as a result of various pathological processes.

Participation of the Vertical Semicircular Canals in Adaptation to Stimulation of the Horizontal Semicircular Canals.

Col. R. N. Kraus, Capt. E. W. Moore, USAF (MC), P. J. Dowd, M.A., and R. L. Cramer, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

It is hypothesized from data on the rapid adaptation to Coriolis stimulations that adaptation to a simple acceleratory stimulation of one set of canals is facilitated by simultaneous stimulation of another set. The data to be presented will compare adaptation to simple acceleratory stimulation of the lateral semicircular canals when only these canals are stimulated and when they are stimulated simultaneously with the vertical canals. These data will contribute to the specifications of training regimens against aerial disorientation.

Life Support in the Small Space Bioprobe.

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Space bioprobes of various types accommodating small animals remain an important means of investigating the effects of the space environment on biological specimens. Successful operation of life support systems for prolonged periods would lead naturally to an investigation of the physiological and behavioral problems associated with prolonged trips into space such as the biological effects of Van Allen radiation on biological specimens and studies of the effects of zero gravity on behavior. Over the past few years the Aviation Medical Acceleration Laboratory, together with the Franklin Institute Laboratories, have investigated many of the problems associated with the design of small animal bioprobes. Using a simulated system, animals have been subjected to the environmental conditions of a proposed bioprobe for as long as 18 days. Observations made during such tests will be discussed together with their significance in bioprobes.

The Head Down Tilt and Adaptability for Aerospace Flight.

Lawrence E. Lamb, M.D. and Capt. James Roman, USAF (MC), School of Aviation, USAF Aerospace Medical Center, Brooks AFB, Texas.

The circulatory system is normally adapted to a +1 g force. How it will react to periods of weightlessness is a matter of considerable importance in

orbital flight. An index of adaptability can be obtained by studying subjects during stress at +1 g, followed by periods of negative g force. This was accomplished by using a simple tilt table. In the feet down position a series of stresses were carried out. The subject was then tilted head down (45° from horizontal position) or exposed to negative 0.7 g force. Three groups of subjects have been studied, a large group of flying personnel who have experienced syncope, a large group of normal subjects and a group of supernormal subjects undergoing vigorous training. A relative bradycardia was commonly noted during negative g force. This was frequently associated with atrial premature contractions, ventricular premature contractions and A-V dissociation. A difference in the groups was noted. The use of the tilt table has the obvious advantage of simplicity and provides for prolonged periods of small negative g force not obtainable in high performance aircraft. This simple test may be useful in studying the effectiveness of various types of training and physical conditioning on improving circulatory adaptability to the stresses of aerospace flight.

Experience with Air Transportation of Patients With Cranio-Cerebral Injuries. CAPT. DAVID E. LANGDON, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Military physicians must rely upon regional diagnostic and treatment centers for critical support in the care of head injuries. The School of Aviation Medicine began a project to ascertain selection criteria, inflight and post flight problems in the transport of head injuries in modern pressurized aircraft. The patients are categorized by acuteness, depth of consciousness, presence of complicating trapped gases in the chest or skull, facial and cranial fractures and other associated injuries. Criteria for selection and the remarkable absence of other than minor inflight and post flight difficulties are discussed.

Toxic Hazards Resulting From Long Term Exposures to Combinations of Potential Space Cabin Contaminants. W. H. LASSEN, S.B., Aerojet-General Corporation, Azusa, Calif.

Small quantities of a large number of extraneous substances are expected to be generated by various subsystems and released into the atmosphere of a manned space cabin. During long term space missions (on the order of one year's duration), potential toxic hazards might develop due to the combined, cumulative effects of certain of these substances. To minimize the weight and complexity of the total life support system, it is desirable to provide subsystems to decrease the formation and/or lower the concentration of only those substances which contribute to hazardous conditions. At present, it is not known which combinations of low concentration, extraneous substances might constitute a sufficient health hazard to justify the use of controlling subsystems. Both aspects of the problem, namely, determination of the cumulative effects resulting from continuous, long term exposure to low level concentrations and the effects resulting from exposure to combinations of numerous substances, are discussed. The equipment, experimental design, and preliminary results of a long range experimental program are reported.

Studies of Cardiac Output and Circulatory Pressures in Human Beings During Forward Acceleration. CAPT. EVAN F. LINDBERG, USAF (MC), HIRAM W. MARSHALL, M.D., WILLIAM F. SUTTERER, MAJ. TERENCE F. MCGUIRE, USAF (MC) and EARL H. WOOD, PH.D., Mayo Clinic and Mayo Foundation, Rochester, Minn.

Six healthy physicians were exposed to varying periods of forward acceleration of up to 10 minutes' duration at plateau levels of 2, 3.5 and 5 g produced by a human centrifuge. The subjects were supported in the supine seated position by a nylon net stretched tightly over a contoured metal frame, with the back elevated 12 degrees in the direction of acceleration. Measurements of cardiac output on the basis of dye-dilution curves recorded at the radial artery with injections of dye into the right atrium were made a total of 29, 30, and 21 times during these exposures to 2, 3.5 and 5 g, respectively. Thirty-five control (1 g) determinations of cardiac output were done prior to and after the 80 determinations carried out during rotation in the centrifuge. In addition, five of the six subjects' outputs were determined five separate times in rapid succession during a 10-minute period in which the centrifuge was stationary. Continuous recordings of right atrial and aortic pressures as well as respirations, heart rate, ear opacity, ear opacity pulse and oxygen saturation of arterial blood were made in the control situation and during exposures to acceleration. Results indicate relatively little change or slight increases in cardiac output up to levels of 5 g forward acceleration when compared with control determinations performed at 1 g. When these accelerations were prolonged up to 10 minutes' duration, the cardiac output remained stable and there were no overt signs of decompensation. Forward acceleration produced significant increases in right atrial pressure from the average of 8 mm. mercury during control conditions (1 g) up to an average of 22 mm. mercury at the onset of exposure to 5 g. Consistent increases in intraesophageal pressure of similar magnitude were noted in the three subjects in whom this variable was recorded; likewise, a consistent increase in mean aortic pressure was recorded in all subjects during exposure to acceleration.

Postural Heart Block. G. W. MANNING, M.D. and G. A. SEARS, M.D., RCAF, CME, EKG Laboratory, Cardiovascular Unit, Victoria Hospital, London, England.

"Postural heart block" was first described by Manning and Stewart in 1942, who reported four cases of A-V block which were reduced to normal in the standing position. Since that time many examples of A-V block in healthy fit young men have been encountered during the course of our RCAF, ECG aircrew selection programme. In this paper the incidence of A-V block, including postural heart block and the possible significance of the findings will be discussed.

Right Bundle Branch Block and Ventricular Hypertrophy Patterns.

G. W. MANNING, M.D. and G. A. SEARS, M.D., RCAF, CME, EKG Laboratory, Cardiovascular Unit, Victoria Hospital, London, England.

The use of electrocardiography in the selection of aircrew has resulted in the discovery of many examples of right bundle branch block or right ventricular hypertrophy patterns in the electrocardiograms of healthy fit young men. The purpose of this report is to review and discuss the incidence and significance of this finding and the indications for further intracardiac investigation. The results of our findings from approximately 20,000 routing aircrew selection tracings will be discussed.

Multi-Channel Personnel Telemetry System Using Pulse Position Modulation.

ADOLPH R. MARKO, ING., Aerospace Medical Division, Wright-Patterson AFB, Ohio.

Personnel telemetry systems are used to obtain physiological information for instance heart rate, respiration, etc., from a human subject without using trailing wires. Most important requirements on such a system are minimum encumbrance, accuracy under different environments, low power drain, small size and weight. Pulse position modulation has several advantages for this type of application. The ratio between effective signal radiated and average power drain is much higher for other modulation systems. Necessary circuitary in the transmitting unit is comparatively simple. A three-channel laboratory model of a pulse position telemetry system has been developed capable of transmitting heart rate, respiration rate and body temperature. Operating time on one small battery is approximately 50 hours, transmitting range 60 feet. A simple cathode ray scope display system is described as well as a system for permanent recording.

The Electroencephalogram During Positive Acceleration.

JOHN P. MEEHAN, M.D. and CAPT. THOMAS J. MCNEY, USAF (MSC), School of Medicine, University of Southern California, Los Angeles, Calif.

Studies were made of the electroencephalogram as a physiologic indicator of blackout and early unconsciousness in man induced by positive acceleration. Fifteen-second exposures at constant acceleration and exposure to gradual onset acceleration of 1.5 g/min. were programmed. Needle electrodes were used. A simple adjustable helmet provided good mechanical support. Results indicated that no alterations in the electroencephalogram occurred during blackout. The ones occurring with loss or recovery of consciousness might have been significant if like changes had not sometimes been noted without such clinical events present. Conscious muscular effort frequently produced motor activity in the electroencephalogram similar to that observed during unconsciousness. The conclusion seems to be, therefore, that the electroencephalogram has doubtful reliability as a sole measure of consciousness in subjects exposed to positive acceleration.

Effect of Elevated Ambient Temperature and Vibration Upon the Rectal Temperature of the Restrained Rat.

HERBERT MEGEL, Ph.D. and FREDERICK M. KEATING, Ph.D., Boeing Airplane Company, Seattle, Wash.

Restrained male rats (140-160 grams) of a Sprague-Dawley strain were exposed to non-lethal elevated ambient temperatures and to vibration. Ambient temperature, vribrational frequency, and duration of exposure were kept constant. The vibrational amplitudes were varied. Rectal temperature of the animals was measured using a thermistor probe. Restrained animals were subjected to varying vibrational displacements (0.0", 0.100", 0.210", and 0.320" double amplitude) keeping frequency (30 cps) and temperature 110° F. (43.4° C.) constant. The rectal temperatures of the animals following a 20 minutes exposure were +3.1° F., +4.7° F., +6.1° F., and +7.8° F., respectively. The incidence of lethality for these animals up to 24 hours following exposure was 0, 10, 25, and 75 per cent, respectively. The experiment was repeated at a different frequency. Varying the vibration displacements (0.0", 0.050", 0.075", and 0.100" double amplitude) and maintaining the frequency (60 cps) and temperature 110° F. (43.4° C.) constant resulted in an increase in rectal temperature of +3.1° F., +6.4° F., +10.5° F., and +14.9° F., respectively. The incidences of lethality up to 24 hours following exposure were 0, 25, 42, and 100 per cent, respectively. At both frequencies, the rise in rectal temperature was correlated with the increase in acceleratory force. In order to determine the mechanism underlying the nature of rectal temperature response to increasing acceleratory forces, animals were sacrificed by exposure to ether anesthesia and immediately vibrated at varying displacements (0.0", 0.050", 0.075", and 0.100" double amplitude) keeping frequency (60 cps) and ambient temperature 110° F. (43.4° C.) constant. This particular set of conditions was chosen because the differential in rectal temperature of the live animals was greater with increasing vibratory amplitudes. Following the 20 minute period of exposure, the rectal temperatures of the dead animals were +2.0° F., +7.9° F., +9.8°

F., and +13.7° F., respectively. The rectal temperatures of the dead animals were not significantly different from those of the live animals exposed to the identical stress conditions. Mechanisms by which elevated rectal temperatures result from exposure to increasing acceleratory forces may possibly be that vibratory energy is translated into heat energy and/or vibration facilitates transfer of heat from the environment into the animal. Although the rectal temperatures of the dead animals were not significantly different from those of the live animals exposed to the same environmental conditions, metabolism and heat transfer mechanisms available to the live animals cannot be disregarded.

Observations of Canal Sickness and Adaptation in Chimpanzees and Squirrel Monkeys in a "Slow Rotation Room."

LT. J. C. MEEK, MC, USNR, CAPT. A. GRAYBIEL, MC, USN, D. E. BEISCHER, Ph.D. and A. J. RIOPELLE, Ph.D., USN School of Aviation Medicine, Pensacola, Fla. and Yerkes Laboratories of Primate Biology, Orange Park, Fla.

Chimpanzees and squirrel monkeys, with both normal and disturbed vestibular function, were subjected to varying degrees of rotation in the Pensacola Slow Rotation Room. The normal animals showed a form of "canal sickness" similar to that observed in normal humans, and adaptation could be observed after exposure of the animals to subcritical stimulation for several days. The manifestations of canal sickness were correlated with labyrinthine function. It was found that canal sickness failed to develop in those animals which exhibited no nystagmus in bilateral caloric tests. These experiments point to the conclusion that in these animals as in man, the canal sickness experienced in a slow rotation room depends upon normal vestibular function. Thus the chimpanzee and the squirrel monkey may contribute considerably to the clarification of the etiology and final control of canal sickness.

The Determination of the Time of Useful Consciousness When Rebreathing From a Full Pressure Suit at 35,000 Feet.

EDWARD L. MICHEL, M.S. and LT. JULIAN L. RAGSDALE, MC, USN, Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

An investigation was conducted to determine the time of useful consciousness of subjects rebreathing from the full pressure suit when their oxygen supply is interrupted at 35,000 feet. The results of these tests indicate that some gain in useful consciousness time can be achieved in this manner. A discussion of the various factors which can alter the end results is included together with a description of a manual dexterity-code comprehension task, used as a basis for determining the end point of useful consciousness.

Radiation Effects on a Manned Space Vehicle Control Loop.

ORVAL H. MINNEY, M.D., Cucamonga, Calif.

The effects on the spaceman directly of ambient radiation may not be the only consideration. There also appears to be radiation effects on electronic equipment, and on stored and structural materials. Accordingly an analysis was made of the radiation effects on the electronic, the life support, and the human components of the control loop. A hypothetical mission was postulated involving a manned lunar landing and return for one man. To this mission profile was integrated the spectrums, rates, and doses of the known ambient space radiations that might be encountered. Transient decrements in performance of the system were checked for mission integrity. Cumulative and permanent effects were used to degrade the mission profile as they became significant. Conclusions were drawn concerning the efficiency of the control loop under ambient irradiation. Equipment and shielding requirements were recommended. The criteria established has special significance in the design of manned nuclear propulsion systems by establishing a base level.

Observations in the SAM Two-Man Space Cabin Simulator. II. Biomedical Aspects.

T. E. MORGAN, M.D. and B. E. WELCH, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Biomedical data obtained during the course of experiments conducted in the SAM Two-Man Space Cabin Simulator will be discussed. These data will include the impact of various experimental parameters such as mission duration, atmospheric composition and cabin altitude on cardiovascular system performance, biochemical variability and fluid balance and fluid compartment shifts. The implication of these and other variables in terms of biomedical monitoring during long duration flights will also be considered.

Routine Partial Pressure Suit Indoctrination; Results of a 2½-Year Program in the Strategic Air Command.

MAJ. HENRY C. MORITZ, JR., USAF (MC), Office of the Surgeon, Headquarters Second Air Force, Barksdale AFB, La. and CAPT. NICHOLAS C. NICHOLAS, USAF (OIC), 4032nd USAF Hospital, Carswell AFB, Texas.

A résumé of the partial pressure suit indoctrination program at Carswell AFB, Texas (one of the largest such operations in the Strategic Air Command) is presented with the material covering the period November 27, 1957 through June 1, 1960. The various phases of the preindoctrination physical examination are discussed and a detailed analysis of successes and failures in this program with particular emphasis on runs aborted due to physical reasons is presented. Equipment problems in this program have

been minimal and the number of aborted runs due to physical factors has decreased as a result of continued experience in this program. Specific failure rates by cause are presented in the interest of providing planning data for medical personnel supporting high altitude programs.

Comparison of Changes in Arterial Oxygen Saturation During Transverse Acceleration as Indicated by Ear Oximetry and by Direct Photometry on Arterial Blood.

MAJ. TERENCE F. MCGUIRE, USAF (MC), HIRAM W. MARSHALL, M.D., A. CLARK NOLAN, CAPT. EVAN F. LINDBERG, USAF (MC) and EARL H. WOOD, Ph.D., Mayo Foundation and Mayo Clinic, Rochester, Minn.

Six experienced men, twenty-seven to thirty-five years old, were exposed to 2, 3.5, and 5 g for ten-minute periods while reclining in the Mercury Astronaut position in a human centrifuge. Centrifuge axis-to-subject distance was 15.5 feet. A Wood-Geraci oximeter was affixed to the pinna of one ear while an earpiece modified to detect arterial pulsations was attached to the other. Both earpieces were supported firmly on a plaster helmet molded for each subject. Simultaneous cuvette oximetry determinations were made during acceleration via an indwelling needle or small catheter in the left radial artery. Catheters also were inserted to the right atrium and the arch of the aorta. An average of five cardiac output determinations were made during each ten-minute run by the indicator dilution technic, with the injection of indocyanine green into the right atrium and detection at the radial cuvette. Ear-pulse changes during acceleration, useful in the headward (positive) acceleration position as an indicator of a critical decline in blood pressure at ear level, did not show apparent definitive changes in the transverse position. The infra-red cell of the ear oximeter apparently functioned well as a plethysmograph, showing an exponential drop in blood volume of the tissues viewed by the instrument during acceleration, which ranged from 0 to 65 per cent. The oxygen saturation values of blood in the heat-flushed ear indicated by the oximeter decreased rapidly during the first minute of exposure to acceleration and then remained relatively stable at this decreased level for the duration of the ten-minute exposure. The average and range of decreases in blood oxygen saturation indicated by ear oximetry were 8 (3-17), 10 (7-15) and 12 (8-25) per cent saturation at 2, 3.5 and 5 g, respectively. The presence of indocyanine green dye in the blood causes the oximeter to indicate falsely high values for blood oxygen saturation. Approximate correction for this effect indicates that in the absence of indocyanine injections for the cardiac output determinations the ear oximeter saturation values would have been approximately 4 per cent lower than the values given above. Direct photometry on arterial blood by means of the cuvette oximeter indicated a qualitatively similar pattern of decrease in oxygen saturation of arterial blood during exposure to acceleration. The magnitude of this decrease was, however, systematically less than that indicated by ear oximetry. Arterial oxygen saturation levels below 85 per cent by cuvette oximetry were encountered in some subjects during exposure to 5 g. These decreases could be prevented by breathing 99.6 per cent oxygen. The discrepancy between ear oximeter and cuvette oximeter saturation values during exposure to acceleration is believed due to the retarded blood flow through the ear caused by the acceleration, with consequent increased extraction of oxygen from the ear blood by local-tissue metabolism. This interpretation is supported by the finding that the discrepancy between ear oximeter saturation values and direct (cuvette) oximetry on arterial blood is considerably larger during exposure to headward (positive) acceleration during which the diminution in circulation to the ear is much more severe than it is in the transverse position.

Observations in the SAM Two-Man Space Cabin Simulator, III. System Operator Performance Factors.

CAPT. RICHARD E. MCKENZIE, USAF (MSC), BRYCE O. HARTMAN, Ph.D., and B. E. WELCH, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

A multi-element assembly of psychomotor tasks were structured to provide a system simulating those which men in space might be expected to perform. The tasks were divided into four functional areas tapping such factors as monitoring, information processing, encoding, etc. The operator schedule was designed to provide data "packages" of two days, with varying signal rates and work periods. With this design we have gained information relative to prolonged operator performance, the effects of time at the task, the effects of signal rate, circadian variation and the effects of extrinsic factors on performance.

Earlobe Oximetry Determination of Oxygen Tension as a Test for Oxygen System Efficiency.

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Oxygen system efficiency may be determined with repeatable accuracy and ease by means of earlobe oximetry. Other methods such as expired gas sampling, alevolar gas sampling, or arterial blood sampling do not produce usable results, are prohibitive in the collection of statistically valid analysis, or require a break in the integrity of the system under evaluation. The determination of the efficiency of an oxygen system under extreme altitude conditions presents very real limitations on what evaluation methods may be used. Any method of test requiring mask removal cannot be considered acceptable at extreme altitude. Intermittent sampling methods by definitions are ineffective in the measurement of continuously changing values. The oximeter measures continuously, negating the chance of the loss of an important point measur-

ing changing values. It does not require a trained test subject. It does not require arterial blood sampling. It does not require mask removal. It does not require a break in the integrity of the system to be evaluated. It does not create extra anxieties in the test subject that might cloud test results. Therefore, collection of statistically valid data is the result. The mission of this paper, then, is to offer the oximeter as the instrument of choice in the evaluation of oxygen systems and to report some methods for its use.

Effects of Inorganic and Organic Buffers on Oxygen Toxicity in Mice.

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The effect of intraperitoneal injections of 2-amino-2-hydroxymethyl-1, 3-propanediol or tris(hydroxymethyl)aminomethane (THAM) and of sodium bicarbonate on the time of onset of convulsions in mice exposed to pure oxygen at gauge pressures of 30, 42, and 55 p.s.i. was studied, using animals injected with isotonic NaCl as controls. Groups of mice were injected intraperitoneally with 1 ml of 0.3M THAM, 0.3M $NaHCO_3$ or isotonic NaCl. The animals were placed in a transparent plastic pressure chamber which was flushed with oxygen and compressed to the appropriate pressure. The times of onset of convulsions were recorded by a single observer in each series of experiments. In the first series this was taken to be persistent muscle spasms of the front legs, and in the second series, generalized convulsions of the animal. The results were plotted in the form of curves showing the relationship between percentage of mice convulsed against time (logarithmically), and the 50 per cent convulsion time determined by inspection of the curves. In the first series of experiments the log 50 per cent convulsion time for the mice injected with THAM was significantly longer than that of the control mice at all pressures. At 42 and 55 p.s.i. the values for $NaHCO_3$ lay between those of THAM and saline. At 30 p.s.i. the log 50 per cent convulsion time for $NaHCO_3$ was shorter than for the other two substances. In the second series of experiments the mice were given three injections of the solution to be tested at three hourly intervals before pressurization. At 42 p.s.i. approximately equal protection against convulsions was afforded by THAM or $NaHCO_3$. This series of experiments would indicate that oxygen toxicity as measured by the time of appearance of convulsions may be influenced by compounds which have an effect on CO_2 storage and excretion.

Effects of Selected Gases Upon Auditory Threshold Shift.

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Temporary auditory threshold shift is usually induced by exposing an ear to loud sound. It may also result from hypoxia. A comparison of noise-induced and hypoxia-induced threshold shift reveals many similarities. It has been suggested that noise-induced threshold shift may be caused by local hypoxia in the cochlea. If this were the case, then any increase in oxygen supplied to the cochlea might act to relieve the usual threshold shift induced by loud sound. Threshold recovery curves were recorded after exposures at each of four intensity levels for subjects while they breathed either air, 100 per cent O_2, or 95 per cent O_2V – 5 per cent CO_2. The magnitude of the shift was independent of the respiratory conditions, while threshold recovery times were significantly different with the various inhalation mixtures.

Computer Simulation of Man-Integrated Systems.

HALIM OZKAPTAN, M.A. and ROBERT GETTIG, M.S., Republic Aviation Corporation, Farmingdale, N. Y.

The success of a system to accomplish a given space mission is dependent upon design capability to establish an optimum allocation of man-machine resources. The increasing complexity of mission requirements and the broadening range of possible man-machine combinations have exceeded conventional methods of efficient analysis and resource allocation. This deficiency has developed in an area which paradoxically demands greater system reliability, but without equally effective operational means of validation. A solution to this problem may be approached through computer simulation. Republic Aviation Corporation has a mathematical model under development for the computer simulation of advanced systems, wherein a primary objective is the design optimization of the man-integrated system. The model is being developed to correlate flight objectives with the capabilities, interactions and limitations of man and machine acting under internal and environmental constraints. Knowledge and techniques from the disciplines of psychology, mathematics, and operations analysis are synthesized in the model to produce a state-of-the-art advancement in man-machine resources allocation. The variability and nonlinearity of human behavior are amenable to simulation techniques which comprehend the relevant probability distributions as well as the spectrum of analytical relationships implicit in the execution of mission requirements. The model will delineate the optimum design utilization of man-machine resources relative to desired system criteria, and can, by feedback analysis, verify or supplement the input criteria itself. By encompassing the effects of individual differences under stress, it should permit the effective allocation of tasks to the human component. Many missions can be simulated and evaluated which utilize different combinations of resources, under different environmental conditions. In addition to helping assure the success of a proposed mission, it should save time, dollars, and—most importantly—lives.

Further Considerations of the Roentgenologic Evaluation of Flying Personnel at Simulated Altitude.

CAPT. GERALD W. PARKER and LT. COL. ROBERT B. STONEHILL, USAF (MC), USAF Hospital, Lackland, USAF Aerospace Medical Center, Lackland AFB, Texas.

Twenty-eight patients with abnormal intrathoracic air spaces or potential spaces have been studied by means of roentgenograms taken with standard portable equipment in an altitude chamber. Eighty-two roentgenograms of diagnostic quality were made. Only one patient demonstrated expansion of his air space when subjected to rapid reduction of barometic pressure. This is the third reported case of radiologically proven expansion of trapped intrathoracic gases while the patient is at simulated altitude, and it supports the theoretical concepts which have been used to justify the grounding of aircrew members with such lesions. This technique is a valuable aid to the aviation medical specialist when confronted with a flyer who has recovered from a spontaneous pneumothorax, has pulmonary symptoms at altitude but not at ground level, or is considered for return to flying status after thoracic surgery.

Aerospace and the Myth of Hypoglycemia.

MAJ. JOHN R. PFROMMER, USAF (MC), USAF Hospital, Wiesbaden, Germany.

The problem of hypoglycemia and its possible consequences in aerospace travel has been considered often, as reflected in the literature on the subject. In this paper, the literature is reviewed and some new evidence presented to suggest that hypoglycemia will not be a factor in limiting space travel.

Development of an Internalized Animal Telemetry System.

CAPT. BRUCE W. PINC, USAF (MSC) and BEN L. ETTELSON, A.B., Air Force Ballistic Missile Division, Los Angeles, Calif., and Spacelabs, Inc., Van Nuys, Calif.

This paper describes a program which successfully developed a surgically implanted single channel biological telemetry system. The limitations of conventional approaches to instrumentation of experimental animals in rigorous environments is described. The practical advantages to be derived from advanced bioinstrumentation techniques is discussed. The background, rationale, design objectives and technical approach employed are outlined. The program results are summarized and some conclusions are presented. A film illustrating the program is shown.

Increase in the Tolerance of Acceleration Stress With the Dimethylaminoethyl Ester of P-Chlorophenoxyacetic Acid.

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Previous studies from this laboratory have demonstrated a pronounced enhancement of the tolerance to acceleration stress in the rat following hypophysectomy. The studies implicated the pituitary adrenal axis as a critical factor in the survival of the rat and pointed to possible involvement of the hypothalamic area of the brain. Attempts were then made to attain a similar enhancement of the resistance to acceleration stress without some of the deleterious effects of hypophysectomy. The new drug lucidril (dimethylaminoethyl ester of p-chlorophenoxyacetic acid) has been shown to enhance the vasopressor effects of adrenalin applied topically to the brain. Administration of lucidril to rats increased the tolerance of a rat population from a median survival time of 10 minutes at 20 G to a median survival time of 24 minutes at 20 G. The low toxicity of the drug and striking effects in animals suggests its possible use to increase the tolerance of humans to high G.

The Effects of Dietary Protein Level and Starvation on the Mucosal Surface of the Small Intestine.

R. W. PRICE, Ph.D., Missile and Space Vehicle Department, General Electric Company, Philadelphia, Pa.

The purpose of this study was to determine whether alterations in the dimensions and composition of the connective tissue components in the mucosa of the small intestine could be correlated with dietary factors. Histochemical and cytochemical methods were employed to ascertain differences in the tissues of control and experimental hamsters. Varying periods of starvation to near death, levels of dietary protein, and abundance of dietary carbohydrate were studied. Depletion of amorphous ground substance and reticulin was observed in the mucosal basement membrane of hamsters on protein poor diets and starvation to near death. A marked reduction in acid mucopolysaccharides and hyaluronidase labile substances was associated with increased numbers of fibroblasts in these starved animals. Cytological degeneration and depletion of nuclear DNA in the mucosal cells were other changes found in hamsters on sub-optimum diets. The PAS positive substances comprising the mucosal basement membrane were polymerized to a greater extent in the animals fed diets rich in protein than in starved or hamsters fed protein free diets. Lymphocytes, which are associated with antibody formation, were located in the luminal portion of the mucosal cells in starved and protein stressed animals. Utilization of these methods as a possible way to detect early indications of degenerative processes during space feeding as well as to evaluate test diets are discussed.

Human Tolerance to Rapid Recompression.

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To insure physiologic compatibility of the rapid recompression capability of the advanced environmental control systems found on future hypersonic

aircraft, a study is described which utilized an altitude chamber to determine human tolerance to various recompression schedules. Subjects were exposed to recompression rates and differentials ranging from 4 psi in 60 seconds to 10 psi in 10 seconds in an attempt to establish tolerance criteria based on subjective and clinical response. Also described is a method of measuring middle ear pressures during decompression and recompression.

Evaluation of Two Communication Models in the Selection of Verbal Units of From One to Five Bit Ensemble.

D. C. RASKIN, M.A., J. J. DREHER, Ph.D. and W. E. EVANS, M.A., Lockheed Aircraft Corporation, Burbank, Calif.

Two communication models are evaluated by an information selection task. Subject performance with a feedback loop is considered in the light of formerly observed perseverative error. Performance and confidence with the two models is quantified and compared.

Factors of Habituation Revealed by Fluctuation of Averaged Evoked Potentials.

ANTOINE REMOND, M.D., Laboratory of Applied Neurophysiology, Hôpital de la Salpêtrière, Paris, France.

The recording of repeated evoked potentials reveals variations of their amplitude or morphology, the importance of which can be visible to the naked eye. These variations were related to the physiological phenomenon of habituation. Much weaker responses can equally be extracted from background electrical activity by average methods developed and perfected after Dawson's original work. A personal technique derived from a phase analysis principle directly shows the development of averages during their growth in a so-called "isochrone curves" form. We have thus been able to follow responses of waking man to various physical stimuli, visual, tactile, auditive in relation to the geometry of stimulation, the topography of derivation, the total duration of the experience, the occurring of intercurrent distractions, provoked or not; efforts of attention, fatigue, drowsiness, etc. . . . The implication of those parameters will be discussed.

An Automatic Processing of EEG Activity.

JEAN LOUIS RIEHL, M.D., M.S., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

It has been shown that activation responses and alpha blocking reactions correspond to an increase in EEG activity, whereas drowsiness and sleep are represented by a decrease in activity. The instantaneous values of frequency (F) and voltage (V) of the EEG wave forms are averaged out and displayed as a function of time (t). The basic equation describing the process is U_A (Unit of Activity) $=f$ (F, V), where $U_A = F \cdot 1/V$. The instrumentation consists of a frequency meter, a bridge rectifier assembly and an analog computer. This method permits the continuous monitoring of cerebral activity and indirectly gives an index of the level of alertness or consciousness.

Weapon System Safety.

M. C. ROBBINS, M.P.H., Boeing Airplane Company, Seattle, Wash.

The complexity of modern weapon system programs and the number of associate contractors involved in them demands that integrated safety efforts be achieved in those programs. The safety objectives should be prevention of (1) personnel injury or illness, (2) civilian or government property damage, (3) national or international incidents. Obviously, the end objective of the total safety program is the conservation of maximum military capability through accident prevention. An integrated safety program has been developed concurrently with the growth of the Minuteman Weapon System. Safety is being considered as a design parameter and will be integrated into all test and operational procedures and controls. Human factor and hardware integration is being achieved early in the design stages, and research and test planning are cognizant of potentially hazardous operations. The management of a weapon system safety effort demands representation and full cooperation from all associate contractors with system safety definition feedback to design and operating group.

The Ventilatory Advantage of Backward Transverse Acceleration.

TERENCE A. ROGERS, Ph.D. and CAPT. HARALD A. SMEDAL, MC, USN, Stanford University, Palo Alto, Calif., and NASA, Ames Research Center, Moffett Field, Calif.

Test pilots have reported less dyspnea when subjected to g-stress in the eyeballs *out* direction than in the eyeballs *in* direction. Six subjects were exposed to stresses of 4, 6 and 8 g in both positions for two minutes, during which measurements of tidal volume and vital capacity were made, using a wedge-spirometer in a closed circuit. In the eyeballs *in* direction, there was virtually no expiratory reserve at only 4 g, and at higher g, the tidal volume was near the limit of the greatly diminished vital capacity. In contrast, each subject had a markedly greater tidal volume and vital capacity at each g level in the eyeballs *out* direction. The results strongly bear out the subjective reports of the greater ease of ventilation in the eyeballs *out* direction.

School of Aviation Medicine Physiological Studies in High Performance Aircraft.

CAPT. JAMES A. ROMAN, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Work at the School of Aviation Medicine with high performance aircraft in subgravity has yielded physiological data in statistical quantities. These show that cardiovascular reaction to subgravity may be quantitated and bears direct relation to cardiovascular be-

havior at positive and negative acceleration values. Representative ECG, respiration and heart rate data are presented for several conditions of flight in high performance aircraft, i.e.: local VFR flights and cross-country flights, both VFR and actual IFR, with weather departures and terminal procedures. These data are discussed in the light of current air traffic control problems and pilot selection policies. Operational problems attendant to biomedical use of high performance aircraft are discussed. Figures are given for the number of flying hours per month to be expected from heavily instrumented high performance aircraft. Instrumentation problems are presented and some of the solutions utilized by the Aerospace Medical Center are discussed. A ten-minute movie is shown depiciting biomedical use of the Center research aircraft.

Chemical Control of Waste Food Putrefaction Within a Space Capsule.

NORMAN G. ROTH, Ph.D., and ROBERT B. WHEATON, M.S., Whirlpool Corp., St. Joseph, Mich.

Chemical systems for controlling odors and gas resulting from growth of microorganisms in waste food in a space feeding console were investigated. The console, which is being developed under contract with Wright Air Development Div., USAF, must contain sufficient food and auxiliary equipment to feed 3 men for 14 days at zero gravity. Dry waste can be effectively preserved with chemical desiccants. A wide variety of germicidal systems were studied for possible use in preservation of wet waste within metal and plastic feeding devices and in a general wet waste storage container. An iodophor system appears to be the best choice. Iodophors studied are low in toxicity and are highly effective broad-spectrum germicides. Their high surface activity provides a mechanism, independent of gravity, for covering the waste food with germicides.

Aeromedical Support of the X-15 Program.

LT. COL. BURT ROWEN, USAF (MC), Air Force Flight Test Center, Edwards AFB, Calif.

This paper will discuss the aeromedical support and personal equipment experience accumulated during the X-15 program. The technique of physiological data acquisition in both the TF-102 and the X-15 will also be discussed. A typical mission schedule and emergency rescue coverage will be described.

Human Crash Deceleration Tests on Seat Belts.

JAMES J. RYAN, M.S., University of Minnesota, Minneapolis, Minn.

Tests have shown that seat-belt forces applied to the human subject in deceleration are sinisoidal in character, are determined by the natural frequency of the spring-mass system and by damping, and are dependent upon the time history of the forces applied at the belt connections. The development of favorable seat-belt characteristics is described. The limiting forces are dependent upon the ability of the pelvic bone system to transmit the sinisoidal rearward and downward forces exerted by the belt on the body. A secondary problem is the rotation of the upper torso about the seat-belt after impact. The results of these force applications from tests are noted. Criteria of aircraft design are suggested to allow maximum impacts without immobilizing injury, permitting immediate evacuation.

An Evaluation of Foot Insulation for Aircrew Personnel.

L. J. SANTAMARIA, B.S., ENS. VERNE M. BUSLER, JR., MC, USNR, and ENS. IRVING P. RATNER, MC, USNR, Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

In the overall evaluation of aircrew protective suit assemblies, a limiting factor in long duration tests has been the protection afforded to the body extremities. Under laboratory conditions, critically low skin temperatures of the fingers and toes frequently cause premature test abortion. In order to eliminate this hazard and the consequent effect on aircrew comfort, a program was initiated to investigate the effects of various types of foot insulation designed to increase exposure tolerance to low temperature. The experimental footwear used in this study was composed of varying layers of cotton, polyurethane, wool, and nylon. Subjective comfort and skin temperatures induced during exposure to an environment of −40° F provided the bases for evaluation.

Limitations of the RBE Concept in the Dosimetry of Ionizing Radiation in Space.

HERMANN J. SCHAEFER, Ph.D., USN School of Aviation Medicine, Pensacola, Fla.

For mixed radiation beams, a full assessment of the total body dosage in rem requires determination of the RBE factors of all components. For ionizing radiation in space, three constituents have to be considered, protons, alpha particles and heavy nuclei. Protons and alpha particles in radiation fields in space exhibit quite different spectral characteristics as compared to terrestrial sources, yet no basic difficulties exist for establishing RBE doses in rem. More complex is the problem for heavy nuclei. For a large fraction of the heavy beam, even estimates of the equivalent rem dose are quite vague due to insufficient knowledge of the basic mode of action on tissue. Recently several authors have reported survival curves obtained with one-time high doses of artificially accelerated heavy ions from linear accelerators. Extrapolation of these data to long-term, low-dosage exposure using established relationships of the target theory leads the RBE concept ad absurdum inasmuch as it furnishes an RBE of infinity for very small doses. The direct experimental approach seems the only way of assessing the effects of heavy nuclei from extended exposure at low dose rate. It is at present still out of reach since it would require exposure times at least of months.

"Black-Out" and Unconsciousness Revealed by Airborne Testing of Fighter Pilots.

CARL WILHELM SEM-JACOBSEN, M.D., Gaustad Sykehus, Oslo, Norway.

To verify and substantiate earlier work, fifty pilots were, during the months of August and September, 1960, tested with airborne EEG recording. The tests were carried out at Wright-Patterson Air Force Base in a F-100 under the supervision of the Aerospace Medical Laboratory. Most of the pilots were selected from different commands and bases. The EEG tracings were supplemented with recordings of the EKG, the respiration, and the flight pattern. Movies were also taken intermittently during simulated combat flight. The results demonstrate that a number of active fighter pilots had brief periods of unconsciousness during manoeuvres frequently flown by T.A.C. fighters. Several had convulsive jerks. It should be noted that some of them, however, on the centrifuge did not black out or lose consciousness when subjected to the same or even heavier G-loads. These observations were made in a number of pilots of whom several had committed "pilot error." No indication of "black-out" or unconsciousness was found in a group of instructors or test pilots subjected to the same examination. The study reveals a reason for "pilot error" and may explain a number of aircraft accidents. Taken into use the test may increase flight safety and decrease the number of unfortunate fatalities.

Shielding of Nuclear-Interacting Secondaries of Cosmic Rays and Solar Particles.

S. P. SHEN, Ph.D., St. John's University, New York, N. Y., and State University of New York, Albany, N. Y.

Some of the more energetic particles occurring in flare-associated Sudden Increases of Solar Particles (SISP) will, upon traversing shielding material, undergo *nuclear* interactions before a sufficient number of *atomic* (electromagnetic) interactions could occur to slow them down. These nuclear phenomena have been discussed by Singer (*J. Av. Med.*, 27:111, 1956) and by others from the astronautic and shielding standpoint. A high-energy proton will give rise to less energetic secondaries (neutrons, protons, pions, light nuclei) by disrupting a nucleus in the shielding material. A high-energy heavy nucleus (if these exist in SISP) will, in addition to disrupting a target nucleus, give rise to secondaries also by its own disruption. If the energy of most of the primaries does not exceed about 600 MeV, as appears to be the case in most SISP but certainly not in the case of non-solar cosmic rays, electron-photon showers produced through neutral-pion decay will perhaps be negligible. The rate of nuclear disruptions induced by primaries and by their nuclear-interacting secondaries as a function of depth in shielding material has been calculated by a few authors as well as by the writer using recent data from accelerator-irradiated targets and cosmic-ray-irradiated meteorites. This depth dependence will be discussed from the shielding standpoint.

Review of Biological Effectiveness of Galactic Primary Cosmic Radiation.

LT. COL. DAVID G. SIMONS, USAF (MC) and JOHN E. HEWITT, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Solar flare and Van Allen radiations are distinguished from Galactic primary cosmic radiation. Three types of Galactic primary radiation patterns are related to observed biological effects. Results of radiation exposures in space and on heavy ion linear accelerators suggest that the damage to the organization of cells as a tissue is more serious than the damage to individual cells. The known variation in Galactic primary cosmic radiation is related to possible variations which would be biologically significant but have not been studied.

Miniaturized Physiological Telemetry Systems.

WILLIAM C. SIPPLE, R. D. SQUIRES, M.D., R. E. JENSEN, Ph.D., and LT. COMDR. J. J. GORDON, MC, USN, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Two types of miniaturized systems for telemetry of physiological signals have been developed, permitting acquisition of data from subjects unencumbered by wiring to recording equipment. In both systems the transmitters are worn by the subject in a helmet or pocket package, with the receivers and recording equipment being located remotely. The first system is for short range applications, with advantages of small size and weight. In the second system the desired signals are converted to frequency modulated subcarriers, multiplexed and fed to a long range F.M. transmitter, requiring discrimination at the recording station. Each of the two systems has its particular advantages determined by the conditions of use and number of channels of information required.

Cold Water Immersion: Estimation of Tolerance Times.

MAJ. GEORGE B. SMITH, JR., USAF (MC) and CAPT. EUGENE F. HAMES, USAF (MSC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Air and sea travelers are always faced with the possibility of being plunged into frigid waters by some catastrophic event. This fact may motivate questions concerning tolerance time of humans immersed in cold water. This paper consolidates the information presently available from human experiences, animal experimentation, and experience with hypothermic anesthesia. The authors present a more useful concept of "tolerance" than the usual life-and-death survival time. They present a method of estimating tolerance and survival times for humans immersed in cold water of various temperatures, allowing for differences in protective clothing.

The Remote Monitoring of Physiological Data From Personnel in Flight.

R. D. SQUIRES, M.D., LT. COMDR. J. J. GORDON, MC, USN, R. E. JENSEN, Ph.D., and W. SIPPLE, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The text of the presentation will be based on the technical and physiological data obtained from studies done at the Aviation Medical Acceleration Laboratory during the past two years. The discussion will attempt to describe a workable total system concept for remote monitoring of physiological data compatible with our experience and the present state of the art. Included will be a discussion of the various physiological transducers tried at the Aviation Medical Acceleration Laboratory.

Evaluation on High Speed and Thunderstorm Effects on Ejections.

COL. JOHN P. STAPP and MAJ. SAMUEL E. NEELY, USAF (MC), Advanced Studies Group, USAF Aerospace Medical Center, Brooks AFB, Texas, and USAF Deputy Inspector General for Safety, Norton AFB, Calif.

Utilizing USAF aircraft accident reports, those accidents involving high speed ejections (both supersonic and over 500 knots) and thunderstorm ejections are analyzed. The influence of high speed and thunderstorm conditions on ejection are evaluated. Five accidents are briefed including a recent multi-jet accident in which both factors were present. Conclusions are drawn concerning the significance of the factors studied.

Crash Protection of Air Transport Passengers by Improved Seat Materials Design.

COL. JOHN P. STAPP, USAF (MC) and BENJAMIN NUTT, M.S., Advanced Studies Group, USAF Aerospace Medical Center, Brooks AFB, Texas.

USAF and RAF crash experience data with forward- and aft-facing passenger seats are reviewed. Human tolerance data derived from quantitative human and animal crash experiments are presented for both forward- and aft-facing seated exposures. A new type of aft-facing seat made with nylon netting in a tubular steel frame is described, in which optimum comfort and protection are combined with minimum weight. Passenger safety requirements of present and future air transports are discussed for both military and civilian operations. Recommendations are made for optimum acceptable protective measures.

Acceleration Protection by Means of Stimulation of the Reticulo-Endothelial System.

LT. E. RICHARD STIEHM, MC, USNR, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

An animal's non-specific resistance to stress is intimately associated with the reticulo-endothelial system (RES). Hypertrophy of these cells is associated with increased resistance to a wide spectrum of stresses, including bacterial invasion, drum trauma, hemorrhage, and X-irradiation. Thus, it was of interest to see if resistance to acceleration stress could be enhanced by such means. Bacterial endotoxin, a potent RES stimulator, was given to rats and their ability to withstand 20 positive G was measured. Tolerance to acceleration was increased 100 per cent in some cases without radical alteration in the animal's metabolism. The conditions for such enhancement of acceleration resistance are presented and the underlying mechanisms discussed.

Thermal Protection Capacity of Aviator's Textiles.

ALICE M. STOLL, M.S., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

Since the advent of high-speed aircraft and nuclear warfare, the need for protection of personnel from thermal injury has been greatly emphasized. Among the more immediate aviation needs is that for fire-resistant anti-G clothing. With this specific need to the fore, an interim method has been devised for the selection and evaluation of textiles on the basis of their resistance to degradation by thermal irradiation of appropriate intensity and their protective capacity when in contact with living skin. At the present time, although field testing is not yet complete, a satisfactory thermally-resistant anti-G suit appears to have been achieved through this effort. The present method is being modified to yield surface temperature measurements during irradiation to provide for the ultimate goal of devising a thermal protection index related to tissue damage integrals.

The Flight Surgeon in Aerospace Research and Development.

BRIG. GEN. BENJAMIN A. STRICKLAND, USAF (MC), Air Research and Development Command, Washington, D. C.

The flight surgeon has always had a vital role in research and development from the onset of our assault of air and space. This paper outlines what the individual flight surgeon is currently doing in aerospace research and development and emphasizes the contribution which the individual squadron flight surgeon may make to this effort. An estimate is made of the need for this activity in the future and a plea is made for more medical officer involvement in the research and development field.

Effect of Hypoxia on Heart and Liver Mitochondrial Respiration and Phosphorylation.

E. H. STRICKLAND, Ph. D., EUGENE ACKERMAN, Ph.D. and ADAM ANTHONY, Ph.D., Pennsylvania State University, University Park, Pa.

Studies on respiration and oxidative phosphorylation were made on heart and liver mitochondria isolated from adult rats continuously exposed to

simulated altitudes of 17,000, 20,000 or 21,000 feet for six weeks. Hypoxia had no effect on the P:O ratios in either heart or liver mitochondria. Some aspects of mitochondrial respiration were altered in altitude rats. Liver mitochondrial respiration of rats maintained at 21,000 feet was lower than that of controls (succinate respiration—30 per cent, ketoglutarate—10 per cent, hydroxybutyrate—20 per cent). However, the observed changes appeared to be associated with debilitation rather than a specific altitude adaptation. On the other hand, heart mitochondrial respiration showed alterations that may be adaptive.

Physical Evaluation of a Polarographic PO_2 Sensor and its Application as a Hypoxia Warning Device.

WING COMDR. R. A. STUBBS, SQ. LDR. A. C. BRYAN and SQ. LDR. W. G. LEACH, RCAF Institute of Aviation Medicine, Toronto, Canada.

A rapid polarographic PO_2 Sensor has been used to follow the exhaled partial pressure of oxygen during decompression experiments. It has been shown that it provides a rapid and effective indication of the onset of hypoxia. It has also been found valuable in following the oxygen tension of the exhaled gas during rapid decompressions and the time it takes the subject and the oxygen regulator to adjust to the reduced barometric pressure. The device is essentially simple enough to be used as a logical in-flight "hypoxia warning indicator" with a visual and auditory readout, or to activate an emergency oxygen supply. The practical difficulties and future of this application are discussed.

Internalized Animal Telemetry System—Biomedical and Surgical Considerations.

GEORGE SULLIVAN, M.D., THOMAS A. SCHULKINS, M.D. and TOBY FREEDMAN, M.D., Spacelabs, Inc., Van Nuys, Calif., and North American Aviation, Los Angeles, Calif.

This paper describes an experimental chronic instrumentation system that makes use of a single channel telemeter to eliminate the disadvantages usually seen in conventional animal instrumentation systems. Discussed are the size and shape of the telemeter unit, the selection of site of implementation and the physiological parameter selected for experimental transmission. The electrode type and location and the introduction of artifacts are discussed as well as the surgical procedure and post operative convalescence. Finally the physiological data obtained and the significance of this data in evaluating the response of the cardiovascular system to severe environmental conditions of loud noise, severe vibration and large G forces is reviewed.

Relationship of Age and Rate of Acquisition of Flying Time versus the Summation of Hearing Loss amongst Canadian Civilian Licensed Pilots.

SENATOR J. A. SULLIVAN, M.B., F.R.C.S. (C), W. E. HODGES, M.A. Sc. and W. A. PROWSE, M.D., Division of Civil Aviation Medicine, Department of National Health and Welfare, Toronto, Canada.

From the results of an audiometric survey carried out on some 732 Canadian civilian private and commercial pilots, licensed to fly in Canada by the Department of Transport in conjunction with the Division of Civil Aviation Medicine of the Department of National Health and Welfare, a relationship was derived with respect to summation of hearing loss for both ears of some 422 commercial and private licensed pilots in terms of age, as well as for some 99 commercial pilots in terms of the rate of acquisition of flying time.

Kinematic Behavior of the Human Body During Deceleration.

J. J. SWEARINGEN, M.S., A. H. HASBROOK and R. G. SNYDER, Ph.D., FAA Civil Aeromedical Research Institute, Oklahoma City, Okla.

The geometry of motion of the head, trunk and appendages was established for one hundred male subjects restrained by a safety belt during forward and side dynamic loadings. Lethal structures of present aircraft seating and cockpit arrangements are revealed by correlating crash injuries with these kinematic data. In addition an analysis of the forces created by body kinematics during forward deceleration sheds new light on seat anchorage problems.

The Significance of Lipid Spectrum Analysis in USAF Test Pilots.

G. DOUGLAS TALBOTT, M.D., Aerospace Medical Division, Wright-Patterson AFB, Ohio.

In a longitudinal cardiovascular evaluation of Air Force personnel over a six-year period, the test pilot personnel of Flight Test Section of the ARDC were studied. Because of its relationship to atherosclerosis, detailed lipid analyses were done before and after formula feedings on these subjects. The test pilots were matched as to age, weight, height and body build with a comparable group of prisoners at the City Prison Farm. Their lipid responses were then statistically compared. Comment is made on the difference of response to fat formula feedings in the test pilots and the prisoners. By virtue of these studies, the inadvisability of utilizing cholesterol as a diagnostic lipid index is presented. All data are demonstrated by lantern slides, the results have been statistically reduced and statistically analyzed.

Performance Tests of a Passenger Oxygen System Designed for Altitudes to 45,000 Feet.

FREDERICK C. THIEDE, Ph.D., JAMES W. RAEKE, M.S., WILLIAM R. SANTSCHI, B.A. and TOBY FREEDMAN, M.D., North American Aviation, Inc., Los Angeles, Calif.

A testing program was accomplished to qualify the oxygen system of the commercial transport version of the T-39 aircraft for FAA certification. Criteria for selection of subjects are presented along with a description of tests in which unindoctrinated subjects were successfully exposed to decompressions of 8,000-35,000 feet in ten seconds and to slow ascents to 45,000 feet. Physiological data acquired during the altitude tests are examined and a method for measuring alveolar pO_2 is discussed. Physiological effects and observations in regard to the adequacy of a revised passenger pressure breathing schedule (four in. H_2O at 45,000 feet) are related to oxygen system qualification for future high altitude commercial aircraft.

Use of the Optical Eye Marker Camera in Aerospace Medicine.

E. LLEWELLYN THOMAS, M.D., C.M., Defence Research Medical Laboratories, Toronto, Canada.

The Optical Eye Marker Camera consists of a motion picture camera worn on a helmet, to record the general field in front of the individual, and an optical system with which the position of visual fixation is recorded on the same film by means of a bright spot of light which moves as the eye moves. The motion picture film obtained therefore records both head and eye movements, showing continuously the visual field of the subject, which changes as he turns his head, and the position of actual visual fixation within this field. The device has been used to study eye movements during rotation on a turntable, and also to record the eye movements of pilots during actual landings, of automobile drivers, and subjects studying various visual displays. Film records from these situations will be shown.

Catechol Amine Excretion in Urine During Simulated Flight.

PERRY R. TILLER, M.A., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Seven subjects flew a prescribed pattern in an F9F simulator under three suit conditions for periods ranging from four to six hours. The three suit conditions were (1) summer flight suit, (2) the Navy's full pressure suit, pressurized to 0.5 psi, and (3) the full pressure suit, pressurized to 2.0 psi. Urines were collected prior to and after each experimental trial for epinephrine and norepinephrine determinations. Results show that there is a marked increase in epinephrine and norepinephrine excretion in the pressure suit conditions over the summer flight suit condition.

Two Years' Experience in Combined Engineering and Pathology Investigation of Aircraft Accidents.

COL. FRANK M. TOWNSEND, USAF (MC), BERNARD C. DOYLE and CAPT. W. HARLEY DAVIDSON, USAF (MC), Armed Forces Institute of Pathology and Civil Aeronautics Board, Washington, D. C.

The Aerospace Pathology Branch of the Armed Forces Institute of Pathology has assisted the Civil Aeronautics Board and the Federal Aviation Agency in the medical investigation of seventeen commercial and/or civil aircraft accidents since November 1957. The work of the Human Factors Committee of the CAB, combined with that of the pathology studies, has assisted greatly in reconstructing the mechanism of injuries sustained in passenger and crew fatalities. A review of this work again emphasizes the necessity of a rearward facing seat in future commercial aircraft with a better system of passenger "tie-down." A continuing effort to improve existing forward facing seats and installation of rearward facing seats on newly certificated transport aircraft will be discussed.

Problems in Air Traffic Management: I. Longitudinal Prediction of Effectiveness of Air Traffic Controllers.

DAVID K. TRITES, Ph.D., FAA Civil Aeromedical Research Institute, Oklahoma City, Okla.

The Civil Aeromedical Research Institute has undertaken a comprehensive research program for the development of psychological techniques useful in selection of personnel for positions within the FAA. Initially, interest is centered on the critical specialty of air traffic controller. Previous research, begun in 1956, indicated that grades and instructor evaluations in air traffic controller school and on-the-job evaluations of performance could be predicted by psychological tests. The sample of approximately 200 air traffic controller trainees used in the earlier study has been followed over the intervening years and additional information collected concerning job performance, promotions, retention in air traffic control work, and medical history. This paper presents the results of the analysis of the additional information and evaluations of the feasibility of selection of air traffic controllers by psychological tests.

Left Bundle Branch Block.

RANDOLPH T. TYNDALL, M.D. and LUDWIG G. LEDERER, M.D., American Airlines, Los Angeles, Calif.

A case of left bundle branch block is presented. This is a complete block which persists for long periods of time, then clears completely. The patient has been asymptomatic. The case is presented because the evolution of the electrocardiographic pattern is unusual. Explanation of the etiology of the block is not given.

Personal Approach to Aircraft Accident Prevention.

HARRY DAN VICKERS, M.D., Little Falls, N. Y.

Approximately 30 per cent of fatal aircraft accidents are due to inadvertent penetration into instrument weather by pilots untrained in instrument flight.

Approximately 30 per cent of non-fatal accidents are due to the inability of the pilot to cope with circumstances requiring maximum skills, which they have once had but have forgotten or lost because of lack of practice. Many survivable private plane accidents are fatal due to the lack of use of shoulder harnesses. Many of the middle-aged and older pilots are having accidents due to deterioration of judgment caused by hypoxia. The FAA now requires a minimal instrument ability of private pilots, but those licensed prior to June 1960 are largely untrained in and ignorant of the danger of IFR and marginal weather. The great majority of private pilots after license never progress beyond student levels of training and ability. These pilots too are usually unaware of their limitations. The need for oxygen at altitude and the life-saving value of shoulder harnesses is largely unrecognized or cast aside by the pilot concerned as unnecessary. The present approach by safety articles, lectures, etc., must be wrong, else we would not have the continuing yearly accident statistics at approximately the same percentages. Pilots are not interested in safety, so they have to be sold. The usual citizen is not interested in health insurance if this is presented to him in an advertisement or an article in a magazine, but he can be sold face to face by a personal salesman. The natural agent to sell safety to pilots is the physician. He has contact with all pilots at least every two years. Pilots generally respect their physician and will heed his advice in matters regarding their health. The medical profession is interested in accident prevention and can do something about it by personal selling of safe flight practices to pilots at the time of their annual physical examinations.

Performance of an Interchangeable, Mobile-Pilot-Restraint-System Designed for use in a Moderately High Acceleration Field.

2ND LT. HUBERT C. VYKUKAL, USAF, GLEN W. STINNETT and RICHARD P. GALLANT, NASA, Ames Research Center, Moffett Field, Calif.

A continuing program has been underway at the NASA Ames Research Center to provide a pilot-restraint system suitable for use in research programs designed to investigate the ability of pilots to perform meaningful control tasks while being subjected to large acceleration forces as would be encountered in re-entry vehicles returning from orbital or lunar missions. Previous investigations have used the NASA contour couch which has proved to be unwieldly to handle and is not interchangeable between pilots. At the present, two modified separate pilot restraint systems have been built and tested at the University of Southern California centrifuge, up to levels of 8 g eyeballs *in*, eyeballs *out*, and eyeballs *down*. Modifications to the support concepts as a result of this testing were made, and this new support system was used in a recent program conducted at the AMAL-NADC Johnsville centrifuge. These systems, in part, are mobile, feature quick ingress and exit, a novel pneumatic bladder back support automatically adjusting to the pilot's contour, and are considered by the user pilots to be equal or superior to previous systems experienced. This paper will describe the various support systems and outline the pilot's acceptance of these systems noting those areas requiring improvement. Consideration will be given to the adaptability of the present approach to vibration and impact stresses.

Physiological Factors in the Training of Aircrew in the Use of RAF Partial Pressure Suits.

SQ. LDR. P. R. WAGNER and FLT. LIEUT. D. BEETON, RAF Institute of Aviation Medicine, Farnborough, England.

In the past four years, 400 aircrew have been trained in the use of their pressure clothing. The results of this training programme are reviewed in terms of the cardiovascular and respiratory changes induced by pressure breathing at ground level and at simulated high altitude. Particular attention is paid to the analysis of the responses of subjects who have failed to complete the training programme.

Audiometric Findings in a Large Air Force Population Sample.

DARYLE L. WALDRON, Ph.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

Air Force Regulation 160-3, dated 29 October 1956, establishes "a program to minimize the undesirable effects of noise on Air Force personnel." This regulation requires that the Medical Service perform audiometric examinations to: (1) establish a reference, or baseline, audiogram for all personnel assigned to duty or training involving the possibility of hazardous noise exposure; and (2) secure follow-up audiograms at regular intervals in order to detect any changes in hearing levels. For the past three years such data have been collected and studied at the School of Aviation Medicine, USAF. This report will present descriptive and comparative data based upon large samples of the reference audiograms. Also, recorded changes in hearing levels over one and two year periods will be described in terms of the frequencies involved, the direction of the changes (toward better and poorer levels), and the extent of such changes.

Observations in the SAM Two-Man Space Cabin Simulator, I. Logistic Aspects.

B. E. WELCH, Ph.D. and T. E. MORGAN, M.D., School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

A series of experiments concerned with the problems of long duration manned space flight have been conducted. These experiments were conducted in the SAM Two-Man Space Cabin Simulator and

ranged from fourteen days to thirty days duration. Data will be presented concerning the general environmental conditions maintained during the flights and the logistic aspects of manned space operations, including oxygen requirements, food requirements in terms of type, calories and weight and water balance.

The Effect of Acceleration on the Relation between Visual Acuity and Luminance Level.

WILLIAM J. WHITE, M.D., Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.

Measurements made in the WADD centrifuge using an Ortho-Rater visual testing apparatus show the effects of positive acceleration on the relation between visual acuity and luminance level. Under conditions of 1 g the expected increase in resolving power of the eye with increasing luminance was found. In repeating these measurements at 3 g and again at 4 g the following relation appeared: acceleration has a significant and progressive effect on visual acuity at all luminance levels, but this effect is most profound at low brightness levels. Thus at the luminance of 0.01 millilamberts the minimum resolvable angle increased from 4.0 minutes at 1 g to 7.59 minutes of arc under conditions of 4 g. At the highest brightness level, 150 millilamberts, the change in visual angle was 0.25 minutes of arc between these two values of acceleration. The data have been interpreted both in terms of decreased blood flow to the head and in terms of distortion of the optical imagery of the eye.

Medical Investigation of Civil Aircraft Accidents.

CARL E. WILBUR, M.D., Federal Aviation Agency, Washington, D. C.

The duties of the Civil Aeronautics Board and the Federal Aviation Agency relative to the medical investigation of aircraft accidents are described. The resources of each for the accomplishment of the task are enumerated. The results of 18 months experience with the routine investigation of air carrier accidents are reviewed. The desirability of extending such investigations to general aviation accidents is discussed.

Effects of Exposure of Human Hands, Feet and Other Skin Areas in a Near Vacuum.

CAPT. CHARLES L. WILSON, USAF (MC), School of Aviation Medicine, USAF Aerospace Medical Center, Brooks AFB, Texas.

One by-product of research and development tests on the USAF MC-3A partial pressure suit has been the study of the effects of a vacuum on exposed human tissues. Some tissue changes which arise during exposure of unprotected parts to near space-equivalent vacuums are: large gas pockets under the skin, venous engorgement, ischemia, petechiae, edema of hands and feet, blisters, and rapid skin dehydration. The hands of twenty human subjects were exposed in a low pressure chamber. Eighteen subjects developed gas under the skin. The gas pocket, which was demonstrated by x-ray and motion picture, always disappeared coincident with chamber repressurization. Skin blisters sometimes developed during other tests adjacent to thick garment seams after an hour or more at near space-equivalent pressures. Similar conditions often produce edema, petechiae, or transient ischemia.

Missile Operations Support.

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It is apparent that there are aviation, medical and industrial hygiene engineering problems related specifically to the missile weapons system. This paper reviews the sources of ionizing radiation and mentions the problems associated with microwave radiation. Problems associated with the toxicities and irritant properties of the missile propellants have been touched upon. These problems are magnified many times by the quantities of these substances which must be handled. Hazardous noises are generated in many areas of the missile complex. Again, as the missile becomes more refined and less and less maintenance is required, it will be necessary to consider the impact of boredom and isolation on crew morals and efficiency. This, in turn may develop a requirement for more rigid medical criteria for selection and classification of missile crews.

Metabolic Waste Management in Aerospace Vehicles.

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The types of wastes evolved in a manned space vehicle have been investigated for missions up to one year duration with a crew of one to three men. It was found that the wastes that would be encountered can be catagorized in respect to mission duration and/or life-support system. Methods of collecting and storing of the metabolic wastes are described in this paper. Particular emphasis has been placed on collecting the wastes in a sanitary, non-toxic, and aesthetic manner to protect the health of astronauts. Methods of disposing of the wastes overboard are also described. Sterilizing of the wastes by various means prior to disposing is necessary. An experimental model of a cabin gas conditioning system for removing gaseous wastes in the cabin is described, as well as a feces and urine collection system, and a waste storage system for use on short missions.

Recovery of Potable Water in Manned Aerospace Vehicles.

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Water is the life-support material required in largest quantity on board manned aerospace vehicles,

and, therefore, will be the supply first considered for recovery or regeneration in the future. Development efforts in our laboratories during the past three years indicate that operational water recovery systems can be made available within one year. This paper summarizes the results of laboratory evaluations and mission application studies to determine the most acceptable techniques and mission durations for which these systems can affect a reduction in take-off mass. Distillation techniques are shown to be best. The results of tests performed on (1) a prototype model of a vacuum distillation water recovery system and (2) an automated experimental model of a compression distillation water recovery system are presented in this paper. Operating charactertistics, control and display requirements and quality of the condensate are accurately known from these tests.

Muscle Strength Under Forward Acceleration.

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Man's ability to utilize his mechanical characteristics under various degrees of forward acceleration is being studied. Maximum hand and arm strengths in six movements with the elbow flexed at a 90-degree angle have been tested through 8 g using an isometric strain gage dynamometer. A nylon net supine seat with a 12-degree back angle served as the body support. Among the parameters studied were intra- and inter-subject variability under both rested and fatigued conditions. Selected anthropometric dimensions were measured on the twenty-two subjects used and possible correlations between these dimensions and the six arm strength movements investigated.

Current Flying and Accident Potential.

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Previous evaluations of the effect of age and experience on aircraft accidents have not incorporated an evaluation of current flying as it relates to these variables. This study considers Air Force jet accidents as these are related to the factor of current flying experience at various age and experience levels in various types of equipment. The results indicate that both the younger and older pilot groups require greater amounts of current flying than do pilots in the middle age categories. This is particularly true in aircraft with exceptionally high performance characteristics. In some instances where inexperienced individuals are flying high performance equipment the accident rate decreases so rapidly in relationship to additional current experience that the actual number of accidents is reduced when greater amounts of current flying are accomplished.

Cosmic Radiation—Laboratory Observations.

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For a number of years this laboratory has exposed monkeys to varying types and doses of acute and chronic radiation using such immediate endpoints as epilation, erythema, desquamation, nausea, vomiting and mortality; and long term endpoints such as shortening of life span and cataractogenesis. In an effort to compare these effects with those which might be assumed from exposure to cosmic ray particles, animals were exposed to high energy protons and alphas, using these same endpoints. These data are compared to previous data for an evaluation of the RBE for certain of these parameters and an attempt is made to estimate the relative hazards of exposure to cosmic radiation.

Subject Selection: Pertinent Criteria for Subjects in Aerospace Human Factors Research.

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Selection of subjects for aerospace human factors research becomes increasingly critical when the results are to be applied to a single human being, such as the operator of an X-15 aircraft or Mercury capsule. Longitudinal analysis of data from subjects in several Air Crew Equipment Laboratory studies has indicated that one carefully chosen subject can often provide more pertinent information than can large groups of randomly selected men. There was a tendency for introversive types of men to deal with anxiety differently than extroversive types do, and to have different psychophysiological patterns. Examples are given of differences in perceptual thresholds, time estimation ability, performance, personality test results, and in physiological measures, found in experimental subjects and which appeared to be related to the manner in which they reacted to stress situations. These meaningful differences are frequently cancelled out by statistical averaging techniques. A thorough mission profile analysis can provide criteria for determining which subjects are appropriate for studies of a particular aerospace problem.