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Ventilation Effectiveness of the Apollo Prototype Space Suit. G. A. ALBRIGHT, M. KUBY, F. B. BENJAMIN, A. BECK and C. G. FRANKEL, Space Environment and Life Sciences Laboratory, Republic Aviation Corporation, Farmingdale, Long Island, New York.

The ventilation characteristics of the Apollo prototype space suit were determined in tests conducted at 35,000 feet simulated altitude in Republic's space chamber. Suited subjects instrumented for electrocardiograms, rectal and skin temperatures performed work on a bicycle ergometer at a constant metabolic rate (1600 BTU/hr.) while the ventilation rate was successively increased from 2.5 to 5.8 CFM STP and at different metabolic rates (1200 and 1600 BTU/hr.) while the ventilation rate was held constant at 4.1 CFM STP.

The ventilation effectiveness is defined as the ratio of the actual amount of moisture picked up by the ventilation stream to the theoretical amount that the stream would be carrying at saturation. This was calculated by measuring the partial pressure of the water vapor in the inlet and outlet streams with a time of flight mass spectrometer and by correcting inlet flowrate measurements to standard conditions. The metabolic heat generated by the subject was calculated by measuring with the mass spectrometer the partial pressure of carbon dioxide in the suit outlet, and converting it by use of mass flow data and the respiratory quotient, into its heat equivalent.

The data was validated by the establishment of a heat balance. At a work load of 1.5 Kp on the ergometer, the heat in BTU/hr. leaving the subject was calculated as: sensible, 149; latent, 1292; mechanical, 250; radiant, — 50; for a total of 1641 BTU/hr. The heat generated metabolically (as indicated by carbon dioxide production) was 1655 BTU/hr.

The experimental results indicate that (1) a ventilation flow rate of 4.1 CFM STP at an inlet pressure of 3.73 psia and saturated at 43° F will permit work performance generating 1440 BTU/hr. (2) the heat removed by the ventilation stream will not be significantly increased by a flow rate greater than 4.1 CFM STP.

Acceleration (+ Gx) Induced Hypoxemia and Crew Performance. W. C. ALEXANDER, R. J. SEVER, W. E. FEDDERSON, and F. G. HOPPIN, NASA Manned Spacecraft Center, Houston, Texas.

A study of arterial oxygen saturation and pilot performance during sustained accelerations similar to those anticipated in the Apollo and subsequent earth entry missions has been conducted in a joint Manned Spacecraft Center—Aviation Medical Acceleration Laboratory program at the Johnsville centrifuge facility. Cabin environments of one atmosphere and one-third atmospheres, with air and 100 per cent oxygen respectively, breathed on demand by the pilot were employed in the study. Data collected from thirty-five professional military pilots demonstrates a resultant diminishing arterial oxygen saturation as a function of magnitude and duration of acceleration and the environment of the pilot. A deterioration in pilot performance was also demonstrated, the extent being dependent upon the severity of the programmed accelerations.

Oxygen Regeneration Test Unit for Zero Gravity Operation. ANDREW D. BABINSKY, Thompson-Ramo Wooldridge Inc., Cleveland, Ohio.

It is shown that regeneration of oxygen by the reduction of carbon dioxide to carbon and oxygen by an electro-catalytic system is competitive with other means of providing oxygen in a closed cabin for medium to long duration missions. This paper will describe the design and test of a unit capable of performing this function.

Carbon dioxide is reduced in a reactor by hydrogen over iron catalyst surfaces. The selection of catalyst configuration will be discussed and experimental results using three distinct catalyst configurations will be given. Method of carbon removal from the reactor shall be described along with the reactor water removal method. Properties of the product carbon (composition, density, surface area, etc.) will be discussed.

Product water is decomposed in an electrolysis unit which was designed based on results of fuel cell research. The cell requires no electrolyte circulation nor rotational motion. Cell characteristics are: 100 amperes per ft^2 at 1.70 volts, power per man —210 watts (including control), cell weight per man—4 pounds, cell volume per man—54 cubic inches.

Four-Man Internal Environmental Simulator. R. A. BAMBENEK, R. A. LANDES, J. HARGREAVES, and B. E. WELCH, General American Transportation Corp., Niles, Illinois, and USAF School of Aerospace Medicine, Brooks AFB, Texas.

This paper describes the design, construction and performance of an internal environmental simulator that will be delivered to the USAF School of Aerospace Medicine in June 1964. This device will be used for physiological and psychological testing of four to six men in controlled artificial atmospheres. Three pressure compartments are provided; namely, the test cell, the airlock, and a small inner lock. With this arrangement it is possible to conduct short-duration equipment tests in the airlock while a long-duration test at different environmental conditions is being performed in the main test cell. Photographs are shown of the cockpit area, equipment bay and sleeping area in the 1000-cubic-foot test cell. Schematic drawings and typical performance data are shown for the environmental control system located in the equipment bay. This system can also support four men in full pressure suits. A unique feature of this chamber is the double-wall construction and method of pressure and leakage control. By holding annular space pressure slightly below the level of the main test cell pressure, contamination of the internal environment by in-leakage is avoided and out-leakage can be controlled between 0 and 5 liters per minute. Automatic control systems are provided for dry bulb temperature, total pressure and partial pressure of oxygen, water vapor and carbon dioxide. Crew safety was the principal design goal with environment control, maintainability and flexibility as the succeeding operational objectives.

Blood Oxygen Changes Induced by Forward (+ G) Acceleration. NATALIO BANCHERO, LUCILLE CRONIN, A. CLARK NOLAN, and EARL H. WOOD, Department of Physiology, Mayo Clinic, Rochester, Minnesota.

Eight dogs under morphine-pentobarbital anesthesia were exposed to forward accelerations of 2, 4, and 6 G for 1 minute and 6 G for 3 minutes while in the horizontal, 15° head-up and 15° head-down positions breathing room air. Exposures to 6 G were repeated breathing 99.6 per cent oxygen. Oxygen saturation and opacity at 800 millimicrons of blood were recorded continously by cuvette oximeters. Pulmonary arterial-venous shunting was estimated from blood oxygen saturations.

No systematic changes in femoral artery oxygen saturation occurred at 2 G while small average decrease was observed at

4 G (4 per cent). Decreases occurred at 6 G averaging 10 (4-16) per cent at the end of the 60-second exposure. Return to control (1 G) values was nearly complete 50 seconds after the exposure. Oxygen inhalation delayed but did not prevent the desaturation. These decreases are believed due to pulmonary arterial-venous shunt over 1 G values, when breathing air, was 17 (11-31) per cent. Values for shunts at 6 G, when breathing oxygen, were similar.

The oxygen saturation of mixed venous blood decreased during the exposures to 2, 4, and 6 G, minimum values occurring about 20 seconds after return to 1 G. The average decrease with exposures to 6 G was 15 (9-27) per cent, recovery from which was not complete at 50 seconds after the exposure.

Changes in blood oxygen saturation were not systematically different when the dogs were tilted to the 15° head-up of 15° head-down positions.

Respiratory amplitude and rate were variable but usually increased during the exposure and recovery periods. The degree of the resultant increase in ventilation tended to be directly related to the magnitude of acceleraion.

Progressive decreases in transmission of infrared light of arterial and mixed venous blood were observed indicating hemoconcentration presumably due to loss of fluid from dependent capillaries during the exposures.

Experimental Animal Decompression to Less than 2 mm. Hg Absolute (General Responses, Recovery, and Mortality) RICHARD W. BANCROFT, JAMES E. DUNN, and WILLIAM D. HABLEUETZEL, USAF School of Aviation Medicine, Brooks AFB, Texas.

To estimate the times of "useful" consciousness, complete collapse, and survival of animals exposed to near-vacuum environments, 125 conscious dogs were rapidly decompressed in either 1 or 0.2 second from 35,000 feet, while breathing oxygen, to a pressure less than 2 mm. Hg abs. Groups of 6 dogs each were exposed to this low pressure for periods of time ranging from 5 to 180 seconds, with and without prior denitrogenation, and then recompressed to 35,000 feet with oxygen in either 5 to 30 seconds. The dogs collapsed within 9 to 10 seconds after decompression, as determined from motion picture films. Simultaneously, the effects of anoxia, water vapor, and other evolved gases were apparent, resulting in a generalized muscle spasticity, a few gasps, momentary convulsive seizures, apnea, and gross swelling of the body and extremities. All dogs exposed for less than 120 seconds survived, despite evidence of lung involvement. Respiration recommenced spontaneously either during recompression or at ground level, providing the heart was beating; otherwise, death was inevitable. The longer the exposure time, the more prolonged was the time for recovery which usually ranged between a few minutes to a few hours, except for 1 dog which exhibited a severe post-decompression paralysis with gradual recovery over a period of several weeks. Exposures of 120 to 180 seconds resulted in approximately 15 per cent to more than 80 per cent fatalities, respectively. Denitrogenated dogs tended to show a slightly better survival rate. As might be expected, the shorter the exposure time and the faster the recompression rate with oxygen, the better were the chances for uneventful and prompt recovery.

Semi-circular Canal Dnyamics Compared in Yaw, Pitch and Roll. W. BARRY, N. KOWALSKI and G. MELVILL JONES, Department of Physiology, McGill University, Montreal, Canada.

The response of the human semi-circular canals to rotational stimuli in the yaw ("horizontal") plane of the head is well established. The following experiments compared this established response with corresponding patterns of response to rotational stimuli in the orthogonal planes of pitch and roll. Stimuli were applied by suddenly stopping prolonged rotations on an electronically controlled turnable. The subsequent time course (time constant) of decay in post-rotational response was determined from both subjective (S) and objective (O) data, the methods of cupulometry and measurement of slow phase eye angular velocity being employed respectively. The results in the yaw plane gave time constants of approx. 10 sec. (S) and 16 sec. (O), which lie in their expected ranges. But in the two vertical planes much shorter values were obtained, namely 5 sec. (S) and 6 sec. (O) in pitch and 4 sec. (S and O) in roll. The yaw-pitch and yaw-roll differences were highly significant ($P < 0.01$) while the pitch-roll differences were not significant. These results imply that error development in the rotation sensing system is 3-4 times quicker in pitch and roll than in yaw, possibly due to quickened cupula restoration in the vertical canals. In normal life on the ground this is presumably acceptable on account of the restricted head movement in pitch and roll compared with the relative angular freedom in yaw. But in flight it is the rolling plane which provides the greatest angular freedom, and the increased rate of error development in both sensation of rotation and compensatory oculomotor response must provide a serious penalty.

The Cornucopia Two-Gas Atmosphere System for Man in Space. R. G. BARTLETT, JR. and C. J. SWET, Johns Hopkins Applied Physics Laboratory, Silver Spring, Maryland.

Among the presently limiting factors in manned space missions are the weight, complexity, and power required for respiratory gas supply and control. There is growing conviction that prolonged missions will require a two-gas atmosphere, which further emphasizes these constraints and provides a distinct incentive for developing lighter and simpler gaseous atmosphere systems. The Cornucopia concept for two-gas atmosphere generation and control attacks this problem through a consolidation of the fluid storage requirements for atmosphere supply, spacecraft propulsion, potable water, and other essential functions in the space environment. In a Cornucopia process, oxygen, nitrogen and potable water are produced in nearly any desired ratio by the off-stoichiometric combustion of hydrazine with either hydrogen peroxide or nitrogen tetroxide in a gas generator. No other combustion-generated species is delivered in physiologically significant concentration, and impurity carryovers appear tolerably small. The O_2-N_2 ratio is controlled by either preprogramming or by feedback from an oxygen sensor. CO_2 is controlled by flushing or chemical absorption or a combination of the two. The same reaction may also provide all thermal management and spacecraft power, with further benefits for atmosphere control. In such cases a high rate of gas production removes much of the CO_2 by flushing, and in so doing also limits contaminant buildup. The Cornucopia approach has been applied to two representative space missions, indicating that two-gas atmosphere supply and control can be thusly achieved without penalty as compared to more conventional single gas systems.

Effect of Prolonged Acceleration on Eating and Performance. JULAINE BEASLEY and BARBARA SELDEEN, NASA-Ames Research Center, Moffett Field, California.

Even though an animal could survive in a modified gravitational environment he might exhibit marked behavioral changes. Of particular interest are possible modifications of behavioral patterns basic to the animal's maintenance, such as eating. This study concerns the effect of acceleration on eating and on two food related behavioral tasks.

Twelve male rats were exposed to 5 continuous hours of acceleration at 5 G one day a week for eight weeks. They were given two hours' access to food at the same time daily under the following four conditions. Groups 1 and 2 were fed for two hours in their home cage. Group 1's feeding was scheduled so they were fed immediately after acceleration on test days, while Group 2 was fed 1½ hours later. Groups 3 and 4 were fed at the same time as Group 1 but had to perform a task to obtain food. Group 3 animals were on a fixed ratio schedule, receiving a food pellet every 5 bar presses. Group 4 animals performed a timing task, obtaining food only by waiting 10 seconds before responding.

Results indicate eating was drastically reduced by acceleration exposure. While a delay of 1½ hours was sufficient for some recovery of eating to occur, normal eating was not restored for two days. Performance on the timing task showed a marked effect as a result of acceleration, however, the fixed ratio behavior was not significantly changed. These results suggest that exposure to accleration can produce changes in behavioral functions and bears further investigation.

Physiological Implications as to Survival from Immersion in 75° F Water. E. L. BECKMAN and E. REEVES, Naval Medical Research Institute, Bethesda, Maryland.

It has been determined in previously reported experiments that immersion at water temperatures of 75° F may be limited by failure of the body's physiological compensatory mechanisms. This investigation was designed to study the physiological responses of subjects immersed to neck level in 75° F water for periods up to 12 hours. Measurements relating to the body loss of heat, energy, fluids, and electrolytes were obtained. It was found that a 12 hour period of immersion could not be tolerated by all of the subjects for various reasons: (1) loss of body heat with a reduction in deep body temperature to below the predetermined limiting temperature of 95° F; (2) extreme discomfort with muscle cramps following prolonged shivering; and, (3) decrease in blood glucose to levels below the predetermined limiting value of 60 mg per cent. The changes in blood morphology, blood electrolytes, oxygen utilization and urinary excretion during the period of immersion, in addition to the physiological changes which caused the termination of some experiments are directly related to tolerance of immersion. It was also found that some subjects experienced "spiritual failure" and terminated the exposure voluntarily for what may be considered as "psychological" reasons. These factors are of importance in survival from the involuntary immersion associated with disasters at sea.

Sleep Deprivation: Neurological and Electroencephalographic Effects. D. R. BENNETT, F. A. ZITER, E. A. LISKE, R. H. MATTSON, J. R. CALVERLEY, and K. L. PRATT, USAF School of Aerospace Medicine, Brooks AFB, Texas, and Wilford Hall USAF Hospital, Lackland AFB, Texas.

The physiological effects of prolonged periods of wakefulness are an important aeromedical problem not only in daily operational flying but for future manned space flights. Within the last decade interest in the effects of sleep deprivation on central nervous system function have been increased. Many of the studies performed have measured performance as well as biochemical parameters. Interest in the effects of sleep deprivation on cerebral cortical excitability was stimulated at Wilford Hall USAF Hospital and the School of Aerospace Medicine following the evaluation of several flying personnel who clinically had a single major motor convulsion following prolonged sleep deprivation. In the neurology textbooks and those dealing with epilepsy general reference is only made to the effects of sleep deprivation on increasing the number and possible severity of seizures in those people with recurrent convulsions. However, only scant information is available on the effects of sleep deprivation in the precipitation of a single convulsion in an otherwise apparent normal individual. The cases to be presented illustrate this point. The EEG abnormalities were detected only after subjecting these flying personnel to sleep deprivation. In one case the patient after 28 hours of wakefulness had a grand mal convulsion during the photic stimulation test. These cases will be presented as well as a summary of the EEG findings in 40 normal controls who underwent 28 hours of sleep deprivation.

Effects of Static Magnetic Fields on Basic Microbiological Physiological Processes. MARTHA D. BERLINER and PETER W. NEURATH, AVCO Corporation, Wilmington, Massachusetts.

Results will be presented of two species of fungi, whose growth and response to stimuli can be accurately measured, which are being grown for periods of a week or more in static magnetic fields of well defined strengths and gradients. The first is *Panus stipticus*, a luminescent basidiomycete, whose light emission of millimicrolumens is measured with a photomultiplier system. Light output of this fungus is a physiological index directly related to its growth, respiration and basic metabolism. The second is a "clock" mutant strain of *Neurospora crassa* which has a continuous circadian (24 hour) cycle of growth which is highly independent of any known external time setting mechanism. This rhythm is evidenced by distinct growth rings of consistent amplitude. All cultures are grown in total darkness at 26° C for the length of the experiment, in a gradient field of $dH/dx = 1150$ oe/cm and $H_{max} = 4200$ oe produced by assemblies of ALNICO permanent magnets. Equal numbers of controls are grown in identical, specially constructed monitored constant temperature chambers. Furthermore the controls are placed in an aluminum dummy magnet setup. Thermocouples embedded in dummy petri dishes are used to establish that temperature fluctuations between a sample and a control are within 0.1° C. The same organisms are also being grown in a 7" iron core 12.5 KW electromagnet, in a uniform field of $H = 8000$ oe and dH/dx 10 oe/cm. A highly regulated power supply is being used to eliminate ripple and fluctuations.

Survival after Decompression to a Vacuum. JOHN BILLINGHAM, NASA Manned Spacecraft Center, Houston, Texas.

Exposure of man to a vacuum is an emergency situation which could occur on space missions or during experiments in space environment simulators. The probability of survival and the degree of subsequent recovery in the survivors will depend on many factors, but principally on the duration of exposure to the vacuum before recompression is completed. Specifications for the design and operation of recompression facilities, and the planning of rescue procedures, will be dictated by physiological, engineering and operational constraints. Examples are given for the Gemini mission and for the space environment simulators at the Manned Spacecraft Center. A program to investigate the physiological, pathological and subsequent behavioral changes in animals exposed for varying periods of time to a near vacuum and recompressed to 35,000 feet altitude with oxygen was considered essential to provide some indication of the probability of survival, the immediate and residual tissue damage, and the subsequent ability to perform tasks. Such a program was initiated by the USAF School of Aerospace Medicine at the request of the NASA Manned Spacecraft Center.

Circulatory and Metabolic Effects of Prolonged Inactivity. N. C. BIRKHEAD, B. ISSEKUTZ, JR., J. J. BLIZZARD, G. J. HAUPT, R. N. MYERS, P. A. LACHANCE, and K. RODAHL, Division of Research, Lankenau Hospital, Philadelphia, Pennsylvania.

Prolonged bed rest has been reported to result in negative nitrogen balance, increased urinary calcium and phosphorus excretion, orthostatic intolerance and decreased physical work capacity. To further study these effects, three regimens of inactivity were studied in groups of 4 healthy male subjects: (1) continuous supine bed rest for 42 days; (2) supine bed rest for 24 days except for two 30-minute periods of either sitting or supine bicycle exercise at 600 kpm/min. daily; and (3) combined lying-sitting inactivity (16 hours supine, 8 hours sitting) daily for 30 days. All subjects were hospitalized in a metabolic ward on a constant measured diet of 2500 calories (77 gm. protein, 74 gm. fat, 385 gm. carbohydrate) and 1700 mg. of calcium. Twenty-four hour urine samples were pooled into 6-day collections and analyzed for nitrogen, creatinine, calcium and phosphorus. Subjects were trained for 18 days before and after each period inactivity by riding a bicycle ergometer at 600 kpm/min. daily for 60 minutes. Alterations in circulatory response to supine exercise at 3 to 4 and 5 to 6 times resting oxygen consumption produced by 42 days of continuous bed rest was determined by catheterization techniques. Immediately before and after all three types of inactivity, the hemodynamic response to 70° head-up tilt was determined by direct recordings of femoral artery and superior vena cava pressures, along with maximum oxygen uptake and pulse rate response to both maximal and submaximal exercise. Continuous supine bed rest resulted in: (1) marked impairment in the ability to tolerate head-up body tilt despite the presence of demonstrable arteriolar vasomotor activity and adequate cardiodynamic response to supine exercise (increases in cardiac output of 116 per cent and 208 per cent of control values with exercise before and 107 per cent and 148 per cent of control values after bed rest); (2) deterioration of physical work capacity; (3) an approximate two-fold increase in urinary calcium excretion. The addition of 60-minutes of daily lying or sitting bicycle exercise to bed rest maintained physical working capacity but did not alter hypercalcinuria nor prevent development of tilt intolerance. Similarly, 8 hours of daily quiet sitting failed to prevent development of hypercalcinura and failed to prevent decrease in physical work capacity, but did prevent tilt intolerance. The ability to separate these effects of prolonged

inactivity may aid in the clarification of the underlying mechanisms.

Electronic Blood Pressure Sampler and Printer. VICTOR W. BOLIE, RICHARD J. GOWEN, JERRY R. TENNANT, and DUANE E. SANDER, Oregon State University, Corvallis, Oregon, United States Air Force Academy, Colorado, and Iowa State University, Ames, Iowa.

The difficulties associated with monitoring blood pressure in man over extended periods with the subject not fully relaxed are well known to clinical physicians and cardiovascular physiologists. A CRT recording from a contact-microphone placed over the antecubital fossa in lieu of the sonic probe of the ordinary stethoscope will readily demonstrate the excessive movement artifact which swamps out the signal, even when the subject is doing no more than walking lazily on a slow treadmill. No part of the body appears to be ideally suited for locating an external sensor of arterial pulses, and the forefinger is perhaps as good as any during treadmill operation, although in some aerospace medicine applications a toe might be more suitable.

The design aim of the equipment described in this paper is to provide automatic detection and printing of the pressure levels of the systolic and diastolic pressures in the arteries of the forefinger, without requiring pulse-amplitude or other trimming and balance adjustments for each different individual. The system, which was designed and tested for semi-portable use in cardiovascular laboratory measurements, consists of a paper-tape printer driven by a pair of digital voltmeters which register the systolic and diastolic pressures as detected by means of special decoding circuits which process, in a rather novel manner, the electrical signals from finger-pulse and cuff-pressure transducers. The measurement cycle is completely automatic, and the only operations required for recording the systolic and diastolic pressures are the insertion of a (relaxed) forefinger into a specially designed unit and pressing a button.

Presented in the paper are the complete design details with circuit illustrations, principles of operation, and preliminary test results. Also included is a critique of the system, and suggested points where improvements could be made in future models.

Proposed Instrument System for the Detection and Analysis of Possible Life Forms, Atmospheres, and Soils of Extraterrestrial Bodies. E. A. BOTAN, J. PHANEUF, and J. LAMBERT, AVCO Corporation, Wilmington, Massachusetts.

An instrument system capable of obtaining knowledge of the possible life forms, atmospheres, and soils of extraterrestrial bodies is discussed.

It is a compact, light-weight and small sized system which can be launched, conveyed, and landed on an extraterrestrial body.

The system can sample and analyze the environment by means of microscopy, absorption microspectrophotometry (ultraviolet, visible and infrared) and emission spectroscopy. The data thus obtained can be converted to telemetry signals for transmission back to earth.

The advantages of microscopy, absorption microspectrophotometry, and emission spectroscopy are manifold. For example, the samples examined can be visually presented through television techniques, yielding information concerning size, shape, cellular, or morphological characteristics of possible life forms. Also, information concerning the chemical composition of the visualized particles would be obtained. The presence of hydroxyls, methyls, amidos, carbonyls, phosphates, esters, double bonds, proteins and nucleic acid are just a few of the chemical structural features that can be determined by absorption spectroscopy. Emission spectroscopy can determine the presence of virtually all the elements in the periodic table of the samples examined. Thus, a comprehensive analysis, inorganic, organic and biological can be made of the particles visualized.

Large Excursion Rotary Tracking of Tragen and Target Light in a Space Station Simulator Revolving at 7.5, 10.0, and 12.0 RPM. JAMES F. BRADY, ROBERT E. URMSTON, and BERNARD D. NEWSOM, Life Sciences Laboratory, General Dynamics/Astronautics, San Diego, California.

The biological ramifications of extended weightlessness being unknown, space vehicles of the near future must possess artificial gravity capability. The required vehicular rotation, however, presents opposing engineering and human performance considerations. An optimal compromise would combine a short radius of rotation with the highest angular velocity not causing significant performance decrement. Analysis of existing literature places this ceiling at 4 RPM.

To investigate the reasonableness of this angular velocity as a performance limit, a study was conducted to measure rotary tracking ability within a space station simulator revolving at 7.5, 10.0 and 12.0 RPM on a twenty foot radius. To potentiate any Corolis and cross-coupled acceleration effects during the tracking tasks, the subjects were required to stand with feet stationary while following a 92 mm. diameter target around a four foot diameter circle, inducing large head and arm movements. Each tracking trial lasted 30 sec. with a total of 6 trials for each of 4 conditions: Before spin up, immediately after spin up of the simulator, prior to spin down from 4 hours of rotation and following spin down. Every other trial was done with the room dark and the target illuminated to increase the possible sensitivity to oculovestibular illusions.

The tracking parameters measured were total time on target, total time on bullseye and mean stylus distance from target center. Results suggest that subjects required only one to three 30-second trials to adjust hand-eye coordination following spin up and spin down.

Study of Speech Discrimination in Noise of Naval Aviators and Naval Aviation Candidates. VERNON C. BRAGG and JAMES W. GREENE, U. S. Naval School of Aviation Medicine, Pensacola, Florida.

Testing the aviator's fitness to perform his in-flight duties must take into account his ability to interpret very loud speech in a background of high-intensity noise such as that found in the cockpit of an airplane. The Naval Aviators Speech Discrimination test was recently proposed to evaluate this aspect of the Naval Aviator's hearing. The test consists of 100 one-syllable words copied on tape from the Central Institute for the Deaf W-22 recordings. These words are played in 100db of aircraft noise at a signal-to-noise ratio of +15db.

The test has been given to three groups: Naval Aviators over forty years of age, Naval Aviators under forty years of age, and Naval Aviation candidates who have not yet begun flight training. The results of these tests and their implications are discussed.

Shift of the Center of Mass of a Man-Seat System during Transient Acceleration. JAMES W. BRINKLEY, EDMUND B. WEIS, PAUL J. MARTIN, and NEVILLE P. CLARKE, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Modern escape systems depend, in part, on rockets for attaining the desired trajectory. In light weight systems including most open seats, the influence of shifts in center of mass with respect to the rocket thrust vector relationship could influence the stability of the system and thus the adequacy of the trajectory and could add to the severity of acceleration environment. This study was done to measure the magnitude and time dependence of the center of mass shift of a lightweight seat-man combination during a transient acceleration resembling that produced by rocket burning of an escape system. The lightweight seat with a subject was suspended on the vertical deceleration tower by three tension force cells. The orientation of the seat was such that the deceleration was directed through the body-seat system the same as the rocket thrust vector in operational systems. Data from the three force cells were analyzed utilizing a digital computer to compute the center of mass of the man-seat combination as a function of time at one millisecond interval, in the plane perpendicular to the deceleration vector. The data show that the change is dynamic in nature and (with peak accelerations of 18 G and velocity change of 30 feet per second) is in excess of one inch for the seat-man system. The magnitude and character of change in center of mass during transient acceleration will be a major factor in the design of lightweight escape systems having a requirement for stability during initial flight.

An Instrument for the Totalization of Heartbeats and Results of its Application. A. E. BROWN, M. FRIEDMAN, and R. H. ROSENMAN, Lockhead Missiles and Space Company, Palo Alto, California, and Mt. Zion Hospital, San Francisco, California.

An instrument to count the total number of times the human heart beats over a period of several days was developed and used in support of a cardiovascular research program conducted by the Harold Brunn Institute of Mt. Zion Hospital in San Francisco. The system operates by collecting the action potentials of the heart and using these signals to operate a small electrocardiographic amplifier. The amplifier is used to drive an associate counting mechanism. The amplifier and power supply are about the size of a pack of chewing gum and the counter portion is constructed from a modified wrist watch movement. The heartbeats register as time on the dial of the watch and are then converted into number of beats. The design philosophy of the instrument is discussed. The paper deals with means of reducing the susceptibility of the amplifier to extraneous noise signals and of preventing inertial activation of the tripping mechanism added to the watch by balancing.

Of primary importance is the placement of the electrodes to detect the electrocardiographic potentials. An electrode placement which minimizes the effect of muscle noise and the effect of signal loss due to changes in heart position is described.

This instrument was worn continuously by a number of people for periods of 48 hours as they went about their normal daily activities. The study included a number of volunteer subjects who were suspected to be coronary-prone and a non-coronary group. A third group of people with a history of coronary heart disease was also used. It was found that there was no major difference in any of the three groups.

CO_2 Measuring Systems for Manned Spacecraft. W. B. BUSH, NASA Manned Spacecraft Center, Houston, Texas.

The level of CO_2 within the breathing atmosphere of manned spacecraft is an important parameter that provides an indication as to the well being of the astronauts as well as the success of the mission. In the Gemini and Apollo spacecraft, as was the Mercury, the atmosphere is circulated through a lithium hydroxide canister to remove metabolic CO_2. In order to monitor the performance of this CO_2 removal system a means of measuring the CO_2 partial pressure in the spacecraft is required.

As a result of these possible malfunctions and a need to provide an indication for replenishing the lithium hydroxide, measurement of CO_2 partial pressure is a valuable monitoring aid to the operational status of the spacecraft environmental control system.

Due to the complexity and difficulty of the measurement, three types of inflight CO_2 measuring systems have been developed. A pH sensitive electrode was successfully used on the Mercury MA-9 mission. A radiation differential absorption technique has been fabricated for the Gemini spacecraft and an infrared adsorption technique is being used in the Apollo. A brief description and comparison of these three measuring systems will be the subject of this paper.

Due to the shortness of the Mercury mission and the state-of-the-art of inflight sensors, Mercury used a pH sensitive electrode technique. This sensor consisted of a glass electrode with a silver-chloride reference immersed in a potassium chloride electrolyte. The electrolyte was maintained around the electrodes and adjoined to the sample gas by a gas permeable teflon membrane. The suit circuit gas passed through this membrane and the CO_2 in the sample gas reacted with the electrolyte to form a weak acid. The pH of this acid is sensed by the electrode and is proportional to CO_2 partial pressure. The resulting signal was amplified and used to drive an onboard indicator and telemetry circuit. This system was very light in weight but had slow response and a short operating life due to the drying of the electrolyte.

Due to the short operating life of the Mercury sensor and also to the anticipated extended length of future missions, a CO_2 sensor utilizing the radiation adsorption technique was developed for the Gemini Mission. This CO_2 system utilizes two parallel radiation chambers. One of the chambers has an ascarite filter in line to remove the CO_2 from the sample before entering the chamber, while the other receives the sample containing CO_2. The difference in the detected output of the two radiation chambers is indicative of the amount of CO_2 present. This difference is then amplified and is used to drive an onboard indicator and telemetry.

To provide a CO_2 sensor for the Apollo Mission and utilize it as a backup CO_2 sensor for the Gemini Mission, an infrared principle CO_2 sensor was developed. This difference in energy at the two transmitted wavelengths provides an indication of the quantity of CO_2 present in the sample and is amplified and used to drive an onboard indicator and telemetry system. This system should have a long operating life and requires infrequent calibration.

The Influence of the After Effects of Alcohol Combined with Hypoxia on Psychomotor Performance. JAMES A. CARROLL, Pan American World Airways, Jamaica, New York.

The present study had as its purpose the determination of the effect which hangover has on human subjects when performing a psychomotor performance task while exposed to varying altitudes up to 13,000 feet. Four levels of alcohol up to 105cc absolute alcohol were studied. A total of twelve conditions were studied.

A standard decompression chamber was used. The test equipment consisted of an oscilloscope display driven by two sine wave generators (a horizontal and a vertical) to produce a moving point reference with a highly systematic pattern on the oscilloscope screen, controlled by a stick control.

A second task situated at eye level was the peripheral vision assembly using eight lights which were lighted alternately in a random fashion. This was utilized as a time splitting task.

Subjective testing was performed ten hours after consumption of alcohol. The test lasted for fifteen minutes, during which five predetermined minute scores were obtained. Subjective symptoms were also recorded.

Data processing included two statistical methods, analysis of variance and the Duncan Multiple Range test. These were performed on both tasks for the effects of alcohol, altitude and a combination of both.

Analysis of variance on the tracking task revealed no significant variance among the test periods. Analysis on the peripheral lighting task revealed significance at the .01 level among conditions and lighting periods. The Duncan Multiple Range revealed no consistent differences for the oscilloscope task but did indicate a significant increase in scores between the first and last test minutes with the lighting task. Therefore, no significance was revealed for any condition, treatment or interaction with either of the tasks employed. Subjective findings were also presented.

Manned Operations in Nuclear Space Systems. JOHN T. CELENTANO, D. AMORELLI, and B. B. ADAMS, Space and Information Systems Division, North American Aviation, Downey, California.

The paper is principally concerned with the use of nuclear propulsion in manned aerospace systems.

The introductory portion of the paper discusses basic nuclear propulsion systems, including associated radiations, both in intensity of special relation to the engine.

Following this introduction, consideration is given to radiation and man including effects of ionizing radiation, human tolerance levels and the "so called" maximum permissible levels.

The philosophy of more reasonable allowable levels is pursued and criteria established.

Methods of providing crew protection are outlined which includes a section on Crew Safety procedures. Space operations are discussed with emphasis upon vehicular maintenance as influenced by the inclusion of a nuclear engine is a special problem area.

The paper closes with a consideration of the influence of nuclear propulsion upon ground support system operations.

Effects of Atmospheric Oxygen Enrichment on Ignition of Fabrics. M. A. CHIANTA and A. M. STOLL, Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania.

To determine the optimal fire-preventive atmospheric conditions attainable in space capsules, the burning patterns of several fabrics in oxygen enriched environments (20-100 per cent O_2)

at 4.6, 7.4 and 10.9 psia have been studied. The times to ignition (I_t) and to total destruction (D_t) (where total destruction occurs) were used as experimental parameters since both appear to be dependent on the total pressure, PO_2 and possibly the P_{N_2}/P_{O_2} ratio. The data demonstrate that at the same fractional concentration of oxygen, both I_t and D_t are inversely related to the total pressure and to PO_2. Conversely, at equivalent PO_2, where the fractional concentrations are different at different pressure levels, I_t and D_t increase directly with increased P_{N_2}/P_{O_2} ratios, suggesting that a damping effect is exerted by the N_2. For instance, at PO_2 of 190 mm. Hg throughout, with a P_{N_2} of 47 mm. Hg, at 4.6 psia, flaming occurs within 20 seconds, while at P_{N_2} 190 mm. Hg at 7.4 psia, flaming occurs at 32 seconds; and at P_{N_2} 375 mm. Hg at 10.9 psia flaming occurs at 48 seconds; the fractional concentration of O_2 being 80, 50 and 34 per cent respectively. Since it appears that the burning patterns can be altered by the "damping effect" of the inert gas, studies have been undertaken with heavier gases with a view to producing this effect at a higher O_2 concentration.

Correlation of Parachute Landing Injuries and Surface Wind Velocity. R. M. CHUBB, E. C. LENTZ and R. H. SHANNON, Life Sciences Group, Directorate of Aerospace Safety, Norton AFB, California.

This paper presents the results of a study of injuries received during parachute landings of pilots who have ejected from United States Air Force aircraft during 1959 through 1963. This study was undertaken to determine the effect of surface winds in producing parachute landing injuries in a group of subjects who were not trained parachutists and who generally did not allow surface winds to affect their decision to use the parachute. It was necessary, however, to consider such factors as weight of the subject and his equipment, landing terrain, visibility, direction of travel and attitude of subject at landing, and parachute damage or instability from various causes.

The discussion includes, therefore, not only the correlation between surface winds and landing injuries, but also the effects of the other factors which produced injury. Since most crewmembers who are ejecting or bailing out of disabled aircraft cannot choose a lower surface wind velocity, recommendations are presented for techniques to minimize landing injuries in high winds.

USAF Rocket Ejection Seat Experience. SAMUEL P. CHUNN and ROBERT H. SHANNON, Life Sciences Group, Directorate of Aerospace Safety, Norton AFB, California.

A summation and analysis of all rocket powered ejection experience in operational aircraft from the first such ejection in October 1958 through 31 December 1963 is presented. This includes a comparison of ejections utilizing ballistic powered seats versus those in which rocket powered seats were employed. Parameters such as terrain clearance at which ejection was initiated, indicated air speeds, aircraft attitude and success rates are discussed.

The changes in pilots' attitudes regarding ejection with the advent of the rocket powered seat is portrayed in correlation with a new series of problems arising from this. The part which the rocket powered seat plays in achieving the final result of complete protection in the event of the necessity to eject from modern day aircraft is poined out.

Effects of Cortical and Subcortical Stimulation on Delayed Responses in Monkeys. S. N. CIANCI, Department of Psychology, University of Michigan, Ann Arbor, Michigan.

Sixty-four brain points in five monkeys were tested for the effect of electrical stimulation during the (a) associative period and (b) retentive period of a delayed response task. Stimulation within the limbic and lower extrapyramidal systems resulted in marked impairment on delayed response performance. Deficits were usually obtained during both intervals. On the other hand stimulation of loci in cortex and basal ganglia resulted primarily in differential effects on learning and memory. No impairment was seen from many probes within the latter areas.

Identification and Potential of Aptitude Test Measures for Selection of Tower Air Traffic Controller Trainees. BART B. COBB, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

As part of a research program aimed at improvement of selection methods for air traffic management personnel, the present study-in contrast to previously reported studies involving Enroute or Center air traffic controller trainees—is focused upon identifying those aptitude measures having the best potential in the prediction of performance criteria for Tower (or Terminal) trainees. Prediction equations derived by multiple regression analyses of data for 44 tests administered to trainees of an experimental sample are validated on a second sample to demonstrate the effectiveness with which selected aptitude measures may be used to supplement selection methods based solely on previous job-related experience. Three of five aptitude areas previously found as most important for Enroute trainees also exhibit major potential for prediction of Tower-training performance criteria. These are represented by tests of numerical ability, non-verbal analogies and air traffic problems. Space-relations fail to emerge as important in the present study and the effectiveness of abstract reasoning is superseded by a logic or inference test measure. Even though substantial predictive efficiency is attained when quotions developed specifically for Enroute trainees are applied to data of the present Tower-trainee samples, better prediction of training performance for the latter group is obtained when composite test scores are based only on those aptitude measures which this study has revealed as most important. The results serve as evidence that both similarities and differences characterize the two types of trainee inputs and suggest the feasibility of implementing differential training techniques for the selection of Enroute and Terminal trainees.

Identification of Variables in Acceleration Physiology. KENNETH R. COBURN, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

The problem of identifying variables inherent in an experimental design has always posed a problem to the research worker, particularly in the field of acceleration physiology. It has been pointed out that it is virtually impossible to duplicate acceleration environments on different centrifuges and this has led to a certain degree of confusion in the literature. In this paper the variables are discussed and certain suggestions are made in an effort to bring about an optimum degree of uniformity in acceleration research.

Effects of Zero-G Parabolic Flight on Certain Hematological and Urinary Parameters in Normal and Labyrinthine Defective Subjects. JAMES K. COLEHOUR, U. S. Naval School of Aviation Medicine, Pensacola, Florida.

Disorientation and increased G forces have been shown to cause hypersecretion of corticosteroids in normal individuals while persons with bilateral labyrinthine defects do not appear to respond similarly. It is well known that increased adrenocortical function of administration of corticoids produces leukocytic changes. In the present experiment twenty-one normals and four subjects wtih bilateral labyrinthine defects (L-D) were subjected to flights consisting of several zero-G parabolas. Flights were made on eight days with one or more of the following test groups selected from the above individuals each day: (1) a normal group experiencing only zero-G conditions, (2) an L-D group also experiencing only zero-G, (3) a normal group subjected to Coriolis acceleration under zero-G conditions, and (4) an L-D group also subjected to both types of the unusual force environments. The following statistically significant changes were observed shortly after the flight: Group 1 had leukocytosis, neutrophilia, eosinopenia, lowered serum lactic acid levels, and increased urinary corticosteroids; Group 2 had only increased urinary epinephrine levels; Group 3 showed leukocytosis, neutrophilia, eosinopenia, and elevated urinary corticosteroids; and Group 4 decreased serum lactic acid levels and increased urinary corticosteroids. The findings of this experiment indicate that there is a physiological response to short-term zero-G flight and that there is a difference in this response between normal and L-D subjects.

Physiological Adaptation of the Human to Short Radius Centrifugation. DOUGLAS R. COLLIER, JR., Douglas Aircraft, Santa Monica, California.

The possible adverse effects of prolonged weightlessness has been a concern to many. A technique that may prove invaluable in space is the provision of artificial gravity by the inclusion of a small short radius centrifuge. Such a centrifuge may provide intermittent conditioning of subjects to an earth equivalent gravity force, a therapeutic remedy in case prolonged weightlessness proves undesirable or may be used solely during the pre-return phase to condition the subject to the high G profile of the re-entry deceleration.

To provide background bases for such hypotheses, an experimental program was initiated in Fall of 1963 to first establish *physiological adaptation* to a two G force at a radius amenable to early earth orbiting space vehicles. Subjects were centrifuged for periods up to 4 hours, 40 minutes at 29.9 rpm, at a maximum radius of 104 inches. Physiological adaptation was definitely established in the cardiovascular and neuro-circulatory systems and is currently being explored to establish criteria for concomitant beneficial *conditioning*. Physiological parameters monitored include BP, ECG, pulse, temperature, respiration and GSR. Psychological evaluation was conducted by interval studies of brightness discrimination and arithmetic solution tasks. Testing was done while turning and during follow-up periods of up to 48 hours after centrifugation. All results to date of presentation of the paper will be given. Preliminary conclusion definitely establish physiological adaptation. This is fully expected to provide a conditioning response that strongly recommends the inclusion of an onboard centrifuge for all future extended duration zero gravitational flights.

Human Vestibular Responses to Repeated Unidirectional Angular Accelerations in Total Darkness. W. E. COLLINS, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

Task-control of arousal was maintained in 10 subjects, each exposed to 200 mild CW accelerations spaced over 10 days. Decelerations were sub-threshold. Pre- and post-tests indicated some bidirectional decline in the duration and the slow-phase output of nystagmus and a marked change in the form of the ocular response.

Measurements of subjective velocity were obtained during several pre- and post-test trials, but never during the habituation series. A directionally specific decline in the intensity of the subjective experience was obtained.

A second post-test was given after one month with no intervening stimulation. The nystagmic reaction remained at its post-habituation level. However, the subjective reaction showed a clear, albeit incomplete, pattern of recovery. Data are discussed from both the theoretical (mechanisms of vestibular habituation) and the practical (vestibular effects during air-or-space vehicle maneuvers) viewpoints.

The Vascular Hyperreactor: A Continuing Aeromedical Problem. JOSEPH J. COMBS, JR., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The etiology, diagnosis, management, and long term prognosis of periodic elevated blood pressures or hypertensive vascular disease continues to be a difficult problem in the aeromedical environment.

Criteria separating the vascular hyperreactor from hypertensive vascular disease, have been established at the School of Aerospace Medicine, and these will be discussed.

The composite group of consult patients, 127, who were found to be vascular hyperreactors has been reviewed. Their performance during special cardiovascular stress testing, as well as history (personal and family) and laboratory data will be compared to the 66 patients in whom a definite diagnosis of hypertensive vascular disease was established. From such a comparison characteristic responses in the vascular hyperreactor group are evident and it is hoped that from careful analysis of their responses we can predict those who may ultimately develop hypertension.

Studies previously reported have clearly shown the cold pressor test does not designate those who will become hypertensive, irrespective of their response. Therefore, other tests are being utilized attempting to forward our knowledge of the natural history of vascular hyperreactivity; its ultimate prognosis and modification of physiological homeostasis in those susceptible flying personnel.

A Multi-Stage Cryogenic Trapping System. JAMES P. CONKLE, JAMES W. REGISTER, and GORDON L. WORTH, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The determination of trace contaminants in a spacecraft, an aircraft or the ambient atmosphere can be divided into several discreet problem areas: sample collection; sample concentration; separation of the individual contaminants; identification; and quantification. The first three of the problem areas can be solved by the utilization of the multi-stage cryogenic trapping system described in this paper. The trapping system utilizes an ice trap at 0°C, a dry ice trap at −73°C and a liquid nitrogen trap at −75°C to fractionate or pre-separate the contaminants in an air sample. Subsequent to the trapping procedures, the materials can be contained in pressure cylinders pending transfer to the analytical laboratory. Materials utilized in this system are non-flammable. Liquid oxygen entrapment in the liquid nitrogen stage is prevented by a unique trap design. The system operates effectively over the pressure range from 760 mm. Hg to 190 mm. Hg. Flow rates may be varied from milliliters/minute up to 1 liter/minute, with a maximum volume of 500 liters of air sample being concentrated. Since the unit is portable and easily operated, it makes the study of air contaminants feasible in locations which do not have facilities for characterization of complex chemical mixtures.

The Role of Psychologically Induced Passive Hyperventilation in Aerospace Safety. MANUEL COPES, Missiles and Space Systems Division, Douglas Aircraft Company, Santa Monica, California.

The problem of hyperventilation in aerospace safety has been largely neglected. This neglect is primarily a result of the present lack of understanding of this *psycho-physiological* problem. With today's complex and costly aerospace systems, it is imperative that attention be devoted to the investigation of the hyperventilation problem.

A large number of aircraft accidents and incidents which have been attributed to such causes as hypoxia, oxygen toxicity and pilot error may have actually been the result of hyperventilation. The failure to determine the correct causative factor may have been due to the confusion of hyperventilation symptoms with those of similar conditions and the unreliability of witness reporting.

Approaches suggested to prevent the consequences of hyperventilation are (1) education of aerospace vehicle operators, (2) continual monitoring of vehicle operators, (3) thorough and immediate examination of aerospace accidents, and (4) special testing for crewmen involved in accidents or incidents before resuming regular flight duty.

It is urged that a program be developed so that the hyperventilation problem can be studied and methods devised to prevent its effects from causing aerospace disasters.

Selection and Training Requirements Specific to Bio-Medical and Human Factors Research in Earth Orbiting Stations. CAROL C. COUCHMAN and ELSIE M. COLE, Space and Information Systems Division, North American Aviation, Los Angeles, California.

Although a number of space system studies have contributed to the data regarding the selection and training of astronauts for system oriented functions and the environmental influences anticipated in earth orbiting stations, little effort has been directed toward the analysis of selection and training implications rising from the bio-medical and human factors experimental requirements in the space mission. This paper covers an analytical study of the knowledge and skill requirements necessary to insure fulfillment of an experimental program and the interacting effect of these with requirements imposed by the spacecraft system and the operating environmental conditions.

Representative of the problems discussed are: (1) require-

ments placed on the crew by their subject participation role; (2) requirements for the inclusion of specialists, such as a physician, in the crew; (3) the integration of personality factors associated with adjustment to prolonged missions with other conflicting requirements; and (4) training methodology to meet the combined requirements, such as surgical skills in the weightless environment.

The data on which this discussion is based include, but are not limited to, studies deriving the requirements for an experimental program to determine the effects of weightlessness on man, military studies regarding adjustment to isolated posts, and results of the Mercury program. Some conclusions are made regarding possible supplementation of the present philosophy of the selection and training of astronauts.

Human Chorioretinal Burns Following High Altitude Nuclear Detonation.

JAMES F. CULVER, NORRIS L. NEWTON, ROBERT PENNER, and ROBERT NEIDLINGER, USAF School of Aerospace Medicine, Brooks AFB, Texas.

During Operation Fish Bowl chorioretinal burns were accidently sustained by two test personnel stationed on Johnson Island. This occurred during a night time, long range, missile-delivered thermonuclear detonation. These injuries were incurred at such a distance due to high altitude and consequent phenomena of the detonation.

The importance of vision suddenly becomes paramount when it is lost or threatened, and can be a more devastating handicap from both psychological as well as a physical standpoint, than almost any other type of injury.

These personnel were examined within the first 24 to 48 hours after injury and were followed daily by ophthalmologists for over six months. The exact size and location of such a retinal injury within a fraction of a millimeter is most important in regard to the visual outcome, and such information is essential as a basis for the prognoses. This is clearly illustrated by carefully controlled visual fields, retinal photographs, and other clinical tests performed during the acute and recovery periods of these two men. Such close documentation has provided us valuable information and is presented, discussed, and illustrated by fundus photographs, visual field charts, and other pertinent clinical observations and findings.

Scientific Responsibility for Testing Non-Sensory Modalities.

EVERETT F. DAGLE, Air Force Cambridge Research Laboratories, Bedford, Massachusetts.

The existence of non-sensory, or paranormal phenomena is often discussed in emotional terms because of the controversy concerning the conclusiveness of the research evidence. Despite the controversy, however, the evidence in support of these phenomena cannot logically be entirely dismissed on the *a priori* grounds that it violates all known principles of science.

Our entry into the space age imposes the demand that we take a positive and courageous approach to advanced techniques and concepts, particularly those which might be related to the mental state of the man in space. It logically follows that, even in the face of ultra conservative opposition, it is the moral and scientific responsibility of the physical and life scientists, acting in concert, to fairly and objectively examine and evaluate the evidence for non-sensory phenomena, and, using the most rigorous of experimental techniques, to test the hypotheses.

Evaluation of the Divers Wet Suit as Considered for Use by Pilots of Helicopter and Fixed-Wing Aircraft.

M. J. DAMATO, and M. H. RADLIFF, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

This investigation was conducted to determine the performance characteristics of the divers' wet suit (3/16" thickness) as protection during cold water immersion in flight emergencies for personnel of both helicopter and fixed-wing aircraft. In both the helicopter and fixed-wing configuration the wet suit was worn underneath the summer flight coveralls. The suits were tested with subjects submerged to neck level in a cold water tank with water temperatures of 55°F, 50°F, 45°F, and 40°F. Evaluation was based on mean weighted skin temperatures (MWST) and rectal temperatures (Tr) and subjective comments recorded at ten minute intervals. In the helicopter configuration, tolerance times ranged from 15 minutes (MWST 25.5°C) to 50 minutes (MWST 26.2°C) in water temperatures of 40°F and 55°F, respectively. In the fixed wing configuration, tolerance times ranged from 25 minutes (MWST 26.0°C) to 55 minutes (MWST 27.3°C) in water temperatures of 40°F and 55°F, respectively. Results indicate that under emergency conditions the wet suit to be worn as suggested in the helicopter configuration would present serious limitations in water temperatures of 50-55°F and below.

Personal Habits among USAF Aircrew Members: A Survey:

JEFFERSON C. DAVIS and DAVID H. BEYER, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The field of aviation medicine concerns itself with all factors relating to the health and effectiveness of the flyer. The influence of personal habits on the health and efficiency of crew members has become ever more important as the demands for prolonged peak performance have increased. This survey was conducted to obtain information about some of the personal habits of USAF flying personnel. A questionnaire survey was carried out among 2,000 flying personnel at 100 USAF bases. Each man was asked to record his medications (prescribed or self-administered), diet, tobacco and alcohol consumption during one assigned 24-hour period. This gave a total of 285 questionnaires for each day of the week. 1,000 of the questionnaires were identified by signature and 1,000 were anonymous.

This study furnishes data and permits an assessment of those personal habits of USAF aircrew members referred to above. It also affords an opportunity to evaluate the health education programs of USAF Flight Surgeons in all four areas. Comparison of data obtained by the two methods gives an estimate of accuracy obtainable on signed histories covering any of these personal habits.

The Physiological Stress of Competitive Athletics.

L. F. DIETLIEN and RITA M. RAPP, NASA Manned Spacecraft Center, Houston, Texas.

Previous efforts to assess the physiological effects of sustained dynamic states have been largely limited to the laboratory. With the advent of improved miniaturized bioinstrumentation and telemetry techniques, the continuous monitoring of individuals under a variety of dynamic conditions (stresses) is now operationally feasible.

The data presented were collected from novices and experts during a number of different competitive athletic events, including: sports car racing, crew, track, skin diving, ice hockey, and skiing.

Physiological parameters measured include: pulse rate, respiration rate, temperature, blood pressure, and biochemical determinations.

These data are compared with those obtained from the Mercury flights from the standpoint of physiological cost to the individual.

Alterations in Intermediary Metabolism Induced by Hydrazine and Hydrazine Derivatives.

A. M. DOMINGUEZ, J. S. AMENTA, and T. J. DOMANSKI, Armed Forces Institute of Pathology, Washington, D. C.

The administration of hydrazine induces a wide variety of biochemical and pathological changes in experimental animals. The accumulation of lipid, for example, and associated glycogen loss in the liver of the hydrazine-treated rat has been established by chemical and histopathologic examination. There exists a correlation between the observed morphologic change and metabolic function as determined in *in vitro* findings. With *in vitro* studies, using liver slices prepared from hydrazine-treated animals, amino acid oxidation is greatly reduced while fatty acid oxidation and total oxygen consumption remained unaffected. Nevertheless, the interpretation that similar observations would obtain in the intact animal remained to be established. In order to evaluate our *in vitro* findings, isotope studies utilizing C^{14}-labelled substrates were initiated in the intact animal. Hydrazine (2 mM/kg., s.c.) was administered to adult male rats and the ability of these treated animals to oxidize specific C^{14}-substrates was evaluated by estimating expired $C^{14}O_2$. A

close correlation was found between our *in vitro* studies and the results observed in the intact animal. The actions of other hydrazine-derivatives of interest to the military establishment, e.g., UDMH, will be correlated with the alterations noted in the hydrazine-treated animals as they relate to carbohydrate, amino acid, and fat metabolism. A method is presented which permits a rapid evaluation of oxidative pathways which may be affected by chemical agents in the intact animal.

Experimental Animal Decompressions to Less than 2 mm. Hg Absolute (Pathologic Effects). JAMES E. DUNN, RICHARD W. BANCROFT, and WEBB HAYMAKER, USAF School of Aviation Medicine, Brooks AFB, Texas, and NASA-Ames Research Center, Moffett Field, California.

During the study on rapid decompressions, of the 125 dogs decompressed, 92 were autopsied at three time intervals: within 30 minutes, 2 to 5 days, and 1 to 3 weeks postdecompression. Gross examination of the tissues was done on all autopsied animals. Lung damage was graded 1+ to 4+ according to the amount of edema, emphysema, atelectasis, and/or hemorrhage present. Microscopic examination of the tissues was performed on selected dogs from the various groups.

The most impressive finding was the absence of major pathologic damage except in the lungs unless the exposure time exceeded 120 seconds. By varying time of decompression and time of exposure to less than 2 mm. Hg, it was possible to separate the pathologic effects of anoxia versus time of decompression. In all dogs, the severity of lung damage increased with duration of the anoxic exposure. In groups with comparable exposure times, the dogs decompressed in 1 second exhibited pulmonary congestion, edema, and hemorrhage, while those decompressed in 0.2 second showed predominantly more petechial hemorrhages and emphysematous changes. Denitrogenation appeared to reduce the incidence and severity of the lung damage. Those animals autopsied at the later postdecompression periods showed evidence of resolution of all lesions, especially in the lungs. For the exposures that were longer than 120 seconds, gross examination of the brains and other organs showed increasing amounts of congestion and hemorrhage. The pertinent microscopic findings will be discussed.

Post-Mortem Pulmonary Changes Occurring in Mice Exposed to 100 Per Cent Oxygen at 740 mm. Hg. JOHN Q. DURFEY, Memorial Sloan-Kettering Cancer Center, New York, New York.

The purpose of the experiment was to determine whether or not there were significant post-mortem changes which might be confused with those resulting from "oxygen toxicity" and to further investigate ions of "oxygen toxicity" itself.

Two groups of Swiss Albino mice were used: one in 100 per cent oxygen at 740 mm. Hg (Columbus, Ohio); one in air. Control of temperature, humidity and CO_2 was obtained (method described).

Following 48 hours of exposure the animals were sacrificed and autopsies performed immediately on ½ of each group. Autopsy was performed on the remaining mice 3 hours later. (Of these oxygen groups, 6 mice had been removed from the oxygen environment and sacrificed after 20 minutes in air.) Immediate autopsy revealed no obvious gross, nor significant microscopic differences.

Autopsy at 3 hours revealed differences in these mice exposed to oxygen, killed in oxygen, and allowed to remain in oxygen prior to autopsy. The lungs were grossly atelectatic, smaller in volume, and "liver-like" in substance. They did not float in the fixing solution. Histological changes revealed oedema, congestion, and marked intra-alveolar hemorrhage. All of these findings were in contrast to the lungs of the other animals. Microscopically (light microscope) there were no other changes ascribable to "oxygen toxicity" in any of the lungs.

It is postulated that exposure to 100 per cent oxygen produces profound and rapid post-mortem changes, many of which heretofore have been ascribed to "oxygen toxicity" per se. This may or may not be the case. It appears that these are physical changes which are subject to individual variation and are easily reversed on short exposure to air. Further investigation is obviously indicated.

Target Velocity, Exposure Time and Anticipatory Tracing Time as Determinants of Dynamic Visual Acuity. EDWIN H. ELKIN, Dunlap and Associates, Inc., Washington, D. C.

Dynamic visual acuity (DVA) refers to the ability of the visual mechanism to discriminate small spatial separations in a visual target which is moving with respect to an observer.

The present study examined the effect on DVA of increasing an acuity target's angular velocity under varying target exposure conditions. DVA test conditions were more "natural" than those of previous studies.

Specifically, the effects on DVA of four target velocities, two anticipatory tracking times, and two exposure times were studied. Minimum separable DVA thresholds were determined at each condition for 12 subjects who monocularly tracked Landolt-C acuity targets which swept in arcs of varying angular distance around them. The average thresholds were computed and compared with each other and with relevant findings of previous studies. In addition, static visual acuity was measured and correlated with the subjects' DVA thresholds.

The present study demonstrated that: a) Dynamic acuity does not deteriorate seriously as target velocity increases; b) Individual lengthening of either the tracking time, the exposure time, or the simultaneous lengthening of both times, improves acuity; c) Static acuity and dynamic acuity are related under favorable target viewing conditions; good static acuity being necessary, but insufficient for good dynamic acuity.

Ocular Motility and Flying Safety. W. L. ERDBRINK and H. S. TROSTLE, U. S. Naval Hospital, Philadelphia, Pennsylvania.

The routine flight physical examination can present a clinical and safety problem in Aviation Medicine since the designated aviator or student pilot may be a potential flying hazard because of his ocular muscle balance. A normal ocular status of flying personnel should never be taken for granted. Acquired motility problems are not common and are associated with injury or disease. However, congenital ocular motility problems are not infrequently seen in skilled aviators and in student pilots since they have been "missed" on routine flight physical examinations. What is to be the disposition of flying personnel who have a disqualifying ocular muscle imbalance?

Flying proficiency and safety still dictates the necessity of single binocular vision with stereopsis associated with a "normal" range of horizontal or vertical phoria. The flight candidate who does not meet these requirements should not be permitted to enter flight training. However, the student pilot with satisfactory flying proficiency or the designated aviator with successful performance should be individually evaluated and every effort made to keep flying. When there is no history of diplopia, and suppression of a deviating eye is present, then, if performance has been demonstrated, the individual should be retained in a flying status. A group of case reports is presented illustrating ocular motility problems in flying personnel.

Cryogenic Systems for Use in Weightless Environments. WILLIAM J. EVON, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

This paper is concerned with new concepts developed in the field of liquid oxygen converter systems for use in weightless environments. Many such systems are currently under investigation and development. However, this paper will be limited to the discussion of two particularly attractive concepts; (1) semi-permeable membrane type and (2) dielectrophoretic or non-uniform electric field type.

Basic theory governing both principles will be discussed along with practical applications and design consideration of both to actual flight hardware. Test data substantiating theory and design will also be pesented.

The systems are proven feasible for use in weightless environments by simulating actual operating conditions during test conditions.

Protective Action of Alkalinizing Agents against Oxygen Toxicity in the Rat. P. FELIG and W. L. LEE, JR., 6570 Aerospace Med. Research Labs., Wright-Patterson AFB, Ohio.

The effects of sodium bicarbonate, tris (hydroxymethyl) aminomethane (THAM) sodium lactate, sodium pyruvate and

sodium acetate on survival of rodents exposed to pure oxygen at one atmosphere were studied. Adult male albino rats weighing 150-200 gms were placed in a controlled environment chamber and given daily intraperitoneal injections of 50 ml./kg. of an isosmolar solution of the various test substances; one group of rats injected with isotonic saline served as controls. In contrast to previously reported studies with organic and inorganic buffers, the chamber was provided with an air lock permitting continuous exposure without any fall in oxygen tension during the injection procedures. Oxygen was maintained at 98.5 per cent ($\pm$ 1 per cent), CO_2 at less than 0.2 per cent, temperature at 73-76°F and humidity at 40-60 per cent. Of the various alkalinizing agents used, only sodium lactate significantly increased survival time as compared with saline controls ($P < 0.01$). In addition, the incidence of hyperpnea and lethargy was lower in the lactate treated group. In those rats that did succumb despite lactate therapy, less than 1 cc of pleural fluid was present at autopsy as compared with a 6-8 cc serous effusion in controls. Using the continuous oxygen exposure technique no protective effect could be demonstrated with sodium bicarbonate or THAM. The possible mechanism of action of lactate and its relation to metabolic alterations in oxygen toxicity will be discussed.

Full Pressure Suit Checkout Console. J. A. FERRO and R. N. PRINCE, MRD Division, General American Transportation Corporation, Niles, Illinois, and NASA Manned Spacecraft Center, Houston, Texas.

Of paramount importance to man's ventures in space is the provision and assurance of the requisite environment for his survival. This paper describes a prototype full pressure suit checkout device which allows the astronaut to determine the capability of his suit to provide this environment. This prototype checkout console was developed as part of a three-phase development program directed by the Crew Experiment Branch of NASA's Manned Spacecraft Center.

Extensive testing is necessary to insure the fitness of pressure suits before a mission in space. Presently, the final acceptance tests occur immediately prior to entry of the astronaut into the space capsule and consist of a variety of suited leakage and backpressure tests conducted by a trained technician with the aid of a manually operated pneumatic test stand. These tests are time consuming. A more rapid checkout procedure is desirable to expedite the overall countdown operation, to reduce man test time, and ultimately to permit automatic suit checkout in space in preparation for astronaut ventures outside the capsule.

The pressure suit checkout console described in this paper was designed to provide the astronaut with a rapid, systematic means for determining his suit fitness. Without assistance, he can run a complete series of tests on his suit in much less time than previously possible. The main features of the checkout console are the automated test program with instructional lighting techniques and the safety devices employed to insure the safety of the astronaut during the test. An astronaut may perform a test or selectable test series merely by depressing appropriate pushbuttons on the console. The pushbutton controls and lighted indicators inform him as to the test status. All test data are permanently recorded.

Safety features include an electrical reset to stop tests and return the system to ambient pressure with ventilation, an automatic relief mechanism, a manual pressure release in the event of overpressure, a pressure rate control, and a test hold control. Conservation of oxygen and test time is provided by limiting the test sequence intervals to a minimum and operating with maximum pressure rates compatible with subject comfort. At any time the operator may extend a test or return to ambient conditions.

Computer Analyzed ECG Waveform Alterations under Stress. M. E. FITZWATER and D. J. CORKHILL, Bioastronautics Department, Philco, Western Development Laboratories, Palo Alto, California.

Practical utilization of ECG data in manned spaceflight has been limited to heart-rate and "eye-ball" clinical monitoring. Most detailed analyses of ECG characteristics have been made on cardiac-abnormal subjects. Results of these analyses are group-descriptive rather than individual-descriptive.

The current study was undertaken in order to determine the related changes in ECG waveform characteristics with respect to changes in the physiological and psychological environment for the individual. Since the individual is a total-response system, precise interpretation of his ECG changes should therefore be defined in terms of predetermined baseline characteristics under imposed conditions.

Results will be available to define subjects norms and limits by experimental condition.

The most important potential application of the study is the development of new data analysis techniques. These techniques utilize relatively simple digitized measures of ECG which are showing promise for reduced telemetry requirements and for practical real-time analysis.

Hematological Problems in Aerospace Personnel. JOHN W. FOFT and HARRY H. MALVIN, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The occurrence of hematological abnormalities and disease in patients evaluated by the Consultation Service, USAF School of Aerospace Medicine, is unusual and in some respects unique. This paper reports on such conditions discovered over a two year period, and includes suspected multiple myeloma, polycythemia rubra vera, iron deficiency anemia, anemia due to abnormal hemoglobin, and others. Almost every hematologic abnormality has been undetected prior to the patient's evaluation at USAFSAM. The changes in every case have been mild, making definitive diagnosis difficult. The observation of some of these diseases in a very early stage presents a valuable opportunity, however, to follow the entire course of the disease, and careful follow-up is vital. The implications of some of the hematologic diseases on flying performance and safety are discussed. Normal hematologic values for this closely selected population are presented.

Human Behavioral, Physiological and Biochemical Responses to Prolonged Avoidance. THOMAS W. FRAZIER, NASA Manned Spacecraft Center, Houston, Texas.

This investigation was directed toward clarification of issues regarding prolonged exposures of human subjects to emotionally stressful conditions. Two pilot-physician subjects were placed in chambers where they performed tasks. The principal task involved instrument panel monitoring. If vigilance decrement exceeded experimently defined tolerances, electric shock was automatically administered as punishment. Biochemical, physiological, and behavioral measures were employed to evaluate effects of exposure to stress conditions. The investigation was prematurely terminated after one week of exposure on the basis of apparent gastrointestinal disturbance of the type noted previously in avoidance experiments which used non-human subjects. Relationships between performance, adrenal output, and gastric functioning are discussed.

Egocentric Visual Localization of the Horizontal as a Function of Lateral Body Tilt. ALFRED R. FREGLY, EARL F. MILLER, II, GERT VAN DEN BRINK, and ASHTON GRAYBIEL, U. S. Naval School of Aviation Medicine, Pensacola, Florida; and R. V. GRONIGEN, The Netherlands.

Three of the authors served as subjects. Each seated in a tilt-chair device and inclined laterally in ten-degree intervals within $\pm$ 90° from gravitational vertical. In each of the nineteen positions including upright the subject was required to adjust a luminous line target viewed against a dark background until it appeared horizontal. The same test was made on thirteen separate occasions. It was found that the location of the visual horizontal varied with posture and to a lesser extent with time. Temporal changes in magnitude of the deviation were found between tests and even within a given test as moment to moment fluctuations (rotary autokinesis). Among all subjects the variable error was least in the upright position and increased curvilinearly with body inclination. In spite of the variability in visual localization of horizontality, the judgments throughout the range of body tilt were qualitatively similar among all subjects and the individual test sessions of each subject. Around upright there was a range (totaling 20°-40° on the average) of body positions in which the deviation was not significant from that of upright.

Inclinations beyond this range caused the E phenomenon to appear and increase bilaterally up to a maximum at about 40°-50° position; with further inclination the deviation reversed direction and passed through the position (60°-80°) of zero deviation to grow as the A phenomenon. Repetition of the test without immediate knowledge of results did not as a rule result in reduction of constant error but there was a tendency for the variable error to decrease with this procedure.

Effects of a Horizontal Homogeneous versus Inhomogeneous Magnetic Field on Mice. B. D. FREMMING, F. L. BELLINO, J. D. DELEO, R. J. BLINZLEY, and A. ZERVINS, Westinghouse Research and Development Center, Pittsburgh, Pennsylvania.

Many references occur in the literature concerning biomagnetic effects and work has been accomplished on micro- as well as macro-organisms. A seeming conflict in the reporting of results has been indicated and the variance in reports seems to hinge on such factors as: (1) the ripple effect of the magnetic field, which if great enough, would produce induced electrical currents in the subject exposed; (2) the axis of the magnetic field, horizontal versus vertical; (3) temperature control between pole pieces of the magnet; (4) homogeneous fields versus inhomogeneous fields. For the purposes of this study, a horizontal axis magnetic field was utilized and two strains of mice were exposed for 14 days, continuously, in both homogeneous and inhomogeneous fields with no detectable ripple and controlled temperature.

The determination of biomagnetic effects on animals larger than mice is difficult due to the unavailability of magnetic fields that are properly controlled, as mentioned in the introduction. Added to this, the difficulty of obtaining a physical area large enough to accommodate significant numbers of even animals as small as mice in an adequately controlled and measured magnetic field presents a difficult problem to the researcher. At present, there is no unclassified experimental evidence on the biological response of a mammal to a continuous magnetic field above 5,000 oersted as may be experienced from magnetic shielding against cosmic radiation or from magnetohydrodynamic propulsion of a space vehicle during man's space travel. Parameters of exposure to magnetic fields must be established and given consideration if we are to design effective magnetic shielding against cosmic radiation or if we are to utilize magnetohydrodynamic propulsion of space vehicles. Both short duration (Moon mission) and long duration (Mars mission) parameters for exposure to homogeneous and inhomogeneous magnetic fields, including ripple and temperature effects, must be given consideration. The possibility of synergistic, antagonistic, or additive effects of the other factors of such an environment as would be found in a space vehicle or lunar base must also be given consideration before exposing a man to continuous magnetic fields.

The Lawrence Radiation Laboratory performed magnetic field experiments exposing mice to a horizontal axis of 14,000 oersted field for periods up to 25 days. They reported no changes in red or white blood counts. However, their experiments differed considerably from the one presented here.

Based on a limited number of two strains of mice exposed continuously for 14 days to homogeneous versus inhomogeneous magnetic fields in which ripple effect was undetectable and temperature controlled, a diminishment of 28.1 per cent in the white blood cell count occurred in mice exposed to a horizontal axis inhomogeneous field. An increase of 30.5 per cent in the red blood cell count, as well as an increase of 14.3 per cent in the hemoglobin, occurred in the mice exposed to a horizontal axis homogeneous field (8,500 to 8,900 oersted.)

Zero Gravity Flight Test of an Instrumented Photosynthetic Gas Exchanger. ROBERT D. GAFFORD, ROBERT V. BAILEY, and FRANK Z. BRILL, Beckman Instruments, Inc., Fullerton, California, Martin Company, Denver, Colorado, and AF SSD(AFSC), Los Angeles, California.

This paper discusses the fabrication and test of an experimental gravity independent photosynthetic gas exchange system which was developed to demonstrate organic conversion of carbon dioxide to gaseous oxygen in the gravity-free space environment. The development program was tailored to the limitations imposed by the flight of a long-range ballistic missile. In addition to the design of the basic algal gas exchange system, the program included the design and test of an integrated temperature control system and necessary instrumentation equipment to provide a self-contained experiment.

In operation in a full-on condition, the unit consumed 64 watts of 28-volt dc electrical power and employed seven segments on a commutated telemetry channel. Integral signal conditioning equipment provided dc voltage outputs to the vehicle telemetry system for all data. The entire system weighed approximately 62 pounds and was contained in a volume of approximately three cubic feet. All functional characteristics were designed to be compatible with performance data derived from analysis of the assigned vehicle. The unit, when charged with an active culture of *Chlorella pyrenoidosa* produced between 45 and 50 cc of oxygen per hour.

The experiment was successfully flown on an Atlas Scientific Passenger Pod Flight on 1 March 1963. The telemetered data clearly indicate that photosynthetic gas exchange occurred both during the launch and free-fall phases of the flight. Anomalous temperatures in the algal suspension were observed during part of the subgravity portion of the flight.

A Semi-Permeable Membrane System for Carbon Dioxide Control. ROBERT D. GIFFORD and DANIEL LUCERO, Space Engineering Department, Beckman Instruments, Inc., Fullerton, California.

A regenerative carbon dioxide removal component is required in the life support system of future manned spacecraft. Units employing regenerable adsorbents require periodic replenishment, and some are producers of trace quantities of atmospheric toxins. Alternatively, strictly physical techniques may be employed. This paper presents a mathematical analysis and the design of a CO_2 system employing the priniciple of differential diffusion through semi-permeable membranes.

Fick's law describes diffusion of a gas through a membrane:

$$\frac{J}{A}_{CO_2} = -D_{CO_2}\frac{dc}{dx}$$

where

J = gaseous diffusion current, A = flow cross sectional area, D = the diffusion coefficient, and $\frac{dc}{dx}$ = the concentration gradient.

All parameters in Fick's equation except the diffusion coefficient are independent of the membrane material. The diffusion coefficient is:

$$D = D_o e^{-E/RT}$$

Where D_0 = reference diffusion coefficient, R = gas constant, T = membrane temperature and E = the activation energy for a gas molecule at the membrane surface. Thus, the characteristic parameter relating a specific gas to a specific membrane is the activation energy. Data on experimentally determined diffusion coefficients and corresponding activation energies for CO_2 with a variety of membranes are presented.

Modification of the selectivity of natural or commerically produced membranes is considered. Fick's law leads to the derivation of the following expression:

$$P = P_o e^{-E_p/RT}$$

Where P = permeability coefficient, P_0 = reference permeability coefficient, Ep = permeability activation energy and T = membrane temperature.

Further,

$$E_p = E - \Delta H_s$$

Where E = diffusion activation energy and ΔH_s = heat of solution of gas in the membrane material. A 2000 fold change in membrane permeability resulting from modification of ΔH_s by means of additives is reported. Preliminary design of a CO_2 removal system employing semi-permeable membranes is presented.

Normal Fecal Flora of Man and Its Alterations under Simulated Space Flight. L. S. GALL, P. E. RIELY, and R. R. CARDENAS, JR., Republic Aviation Corporation, Farmingdale, L. I., New York.

The intestinal bacterial flora of normal man is of fundamental

importance, but remains incompletely described; especially with respect to the anaerobic bacteria. Knowledge of normal fecal flora is essential in space research (1) because conditions of space flight, such as diet, atmosphere, radiation, etc., may alter this flora with unknown results, (2) to aid in solving fecal waste disposal problems in space flight, and (3) to better understand the functioning of a closed ecological system. The preliminary results of a NASA-sponsored program to study the normal fecal flora of man will be presented as a basis for the discussion of these problems.

Both aerobic and anaerobic bacteria are present in the normal feces and although there is voluminous literature on the aerobic flora, little is known about the anaerobic bacteria. A study of the fecal samples of forty "normal" humans shows the obligate anaerobic bacteria outnumber the aerobic bacteria by one thousand to one million times. These findings establish that obligate anaerobes predominate in the normal feces and occur in approximately one trillion per gram. This is of special importance because the anaerobes in the feces have been so poorly described and, therefore, their potential role in the body is not known. Also, this anaerobic flora may well be influenced by the high oxygen atmosphere or diets used in space flight. Currently, work is being done to characterize the predominating anaerobic bacteria isolated most frequently.

Evolution of the Life Sciences in the Aerospace Industry. CHARLES F. GELL, Ling-Temco Vought, Dallas, Texas.

The author discusses the gradual and increasingly favorable organization of well-trained and effective cadres of Life Sciences disciplines in the technical framework of the Aerospace Industries. He specifies the following factors as the cause of the earlier difficulties in the establishment of Life Sciences in the Aircraft Industries as due to (a) a relatively large margin of safety in early aircraft manufacture which allowed for less definition of human engineering effort in support of the design, (b) a heavy reliance on the military aeromedical laboratories for human engineering assistance and (c) a minimum of rapport between the Aeroengineer and the Life Scientist.

The nuclei of early Life Sciences organizations in aerospace industry is described and their growth into several functional organizational groupings is discussed. The advantages gained by those aerospace industries that had Life Sciences organizations relatively early over the industries which neglected the Life Sciences as an organizational entity are defined. The attitude and urging of the Armed Forces—National Research Council Committee on Bioastronautics for the reinforcing of the aerospace industries with in-house Life Sciences organizations is discussed. The subsequent influx of Life Sciences professionals, the build-up of in-house Life Sciences laboratories, the establishment of professional relationships with Life Science faculties of local universities and the permanent establishment of a functional organizational niche in the aerospace industry are described.

The future of Life Sciences in the aerospace industry as an expanding field of satisfactory, professional endeavor both in research and systems design and the related career opportunities for Life Scientists are discussed in detail.

Urinary Changes in Man Induced by Rotation. G. J. GOBLE and BERNARD D. NEWSOM, Life Sciences Laboratory, General Dynamics/Astronautics, San Diego, California.

It has been suggested that some of the problems associated with weightlessness can be overcome by rotating the spacecraft. To explore the feasibility of this approach the following study was undertaken. Human volunteers were rotated in a twenty-foot radius Manned Revolving Space Station Simulator to ascertain the effects on excretory function. The urinary electrolyte changes were measured during and after four-hour exposures at different RPMs and will be reported. These include sodium potassium, calcium, glucose, protein, specific gravity, pH and total urine precipitates.

These data demonstrate the interrelationship between electrolyte concentrations and changes in rotation speed and mission duration. Results indicate these changes may be used to assess adaptation to the rotating environment.

X-Ray Cinematographic Observations of the Motion of Animals Exposed to Mechanical Vibration. DAVID E. GOLDMAN and J. B. BOORSTIN, Naval Medical Research Institute, Bethesda, Maryland.

One result of the exposure of animals to intense mechanical vibration is damage to the cardio-respiratory system. This damage arises from relative motion of the viscera with the impact of the heart and lungs on each other and on the chest wall. A high speed X-ray cinematographic unit, able to record at speeds up to 400 frames per second for 40 to 50 frames and over areas of about 50 square inches is being used to examine visceral motion in order to correlate it with pathological effects. The equipment can also be used with human beings. Some of the photographic observations and their analyses will be represented, mostly in the form of motion pictures. When the excitation is sinusoidal, the motion is nevertheless quite complex and depends markedly on the intensity, mode of application, and frequency of vibration.

Nuclear Medical Methods in Aerospace Medical Research. E. H. GRAUL, Department of Radiobiology & Isotope Research, University of Marburg, Marburg/Lahn, Germany.

Modern passenger aviation is on the threshold of supersonic transport flight, which means a constant increase in the demands placed on the physical and psychological condition of those involved. Because of the heavy stress imposed upon astronauts during satellite flights and in future interplanetary flights, it is necessary to make a careful study of their physical fitness.

Although nuclear diagnostic medicine and clinical research with radionuclides have already reached a high level, they have not yet systematically applied to problems in aviation and space medicine.

The advantages which research in nuclear medicine has to offer for aerospace medicine can be indicated by referring to developmental projects which we have established in this field:

1) Simultaneous cardiac and circulatory diagnostics by means of the simultaneous radio-cardiocirculographic technique enlarging the excellent basic work done by Donato and Monasterio. It is only through *simultaneous* registration of various measurement data, such as impulse rates over the right and left sides of the heart, electrocardiograph readings, arterial and venous blood pressure, etc., that reliable conclusions can be drawn on the *functional* reactions of the heart and circulatory system to rest and stress. The article presents the measurement data obtained from cardiac and circulatory patients and from healthy persons under various stresses and also after exposure in a climate chamber, together with a description of equipment which was especially developed for these purposes.
2) Possibilities of reducing the radiation burden in nuclear diagnostic medicine through
   a) choice of suitable radionuclides (e.g., VB_{12} test with radio-cobalt, initial thyroid test with various iodine radionuclides.
   b) tests in vitro *without* incorporation of radionuclides in thyroid-function tests.
   In this case, tests can be carried out without imposing any radiation burden whatsoever on the patient or test subject. The T_3 serum test with gel filtration, as developed by us, is also presented in this connection.

   Further examples of the potential use of radioisotopes in aerospace-medicine research, such as determination of total body-water and extracellular space, ferrokinetics, vita-determination of erythrocytes, etc., are also discussed. In conclusion, the possibilities of combining biophysical and radioisotope methods are pointed out, which could lead to a further increase of information in this field.

Maintaining Cardiovascular Reflexes During Simulation of a Zero Gravity Effect: An Experimental Study. C. GRAVE, J. E. MABRY, and D. H. STUHRING, The Boeing Company, Seattle, Washington.

To simulate the expected 0-g effect on cardiovascular reflexes, four subjects remained in horizontal plane during four consecutive four-day periods (16 days total). Subjects were exposed to

a 15-minute, vertical, tilt-table test after each four-day period. Blood pressures and pulse rate were obtained during tests. An exercise apparatus was used consisting of two vertical trampolines ten feet apart and a cart supported by casters and on rails. Subjects rode the cart and were impacted against the trampolines. Duration of impacts was a minimum of 400 m.sec. at 1.0-1.5 "g's." Bathroom scales were used as a second exercise device.

Each subject was exposed to four experimental conditions of four-day duration. The conditions were:

1. *Bedrest*—Subject remains in bed for four-day period.
2. *Passive Trampoline*—Subject is impacted on trampoline device (same height as beds used in experiment) by another person during ten 15-minute periods per day and remains in bed at other times.
3. *Active Trampoline*—Subject uses legs to impact self on trampoline device during ten 15-minute periods per day and remains in bed at other times.
4. *Isometric*—Subject performs whole-body isometric exercise against scales and during ten nine-minute periods per day while in bed.

The experimental design was a 4 x 4 Latin square. Table I presents the averages of lowest pulse pressures (mm. Hg) obtained during vertical, 15-minute, tilt-table test for a baseline reading prior to the experiment and after each four-day experimental condition.

TABLE I. AVERAGES OF LOWEST PULSE PRESSURE OBTAINED DURING TILT TABLE TEST (mm. Hg)

Baseline	Passive Trampoline	Active Trampoline	Isometric	Bedrest
30.5	30.0	16.0	31.5	7.8

The only average which is significantly different from the Baseline ($p < 0.05$) is the one for the Bedrest condition. Also, Passive Trampoline and Isometric conditions are significantly more effective that the Active Trampoline condition. Cardiovascular reflexes were not only maintained during bedrest by the conditions described but were reconstituted after debilitation occurred.

A Comparison of US and USSR Bioastronautics. DUANE E. GRAVELINE and HUBERTUS STRUGHOLD, Aerospace Medical Division, Brooks AFB, Texas.

The Soviet bioastronautics program, as it has evolved from the initial animal carrying vertical rocket flights to the manned orbital series, has been reviewed and compared to the United States' bioastronautic effort. An early comprehensive animal and biopackage evaluation program provided the Soviets basic and detailed biologic information upon which to plan and support their manned flights. Selection of a younger group of cosmonauts and inclusion of a relatively inexperienced female in their cosmonaut group reflect significant differences in selection criteria. Choice of a sea-level equivalent cabin and broad bioinstrumentation coverage reveal additional departures from United States' philosophy. Prolonged zero gravity consideration and certain aspects of man-machine relationships are other areas where the approach of the Soviet scientists have been substantially different from that of the United States.

It is evident that the Soviet program has effective scientific input at a very high administrative level and has resulted in a carefully conceived and executed bioastronautics program supported by a broad base of valid scientific information.

Vestibular (Canal) Sickness Precipitated in the Weightless Phase of Zero-G Parabolas by Coriolis Force. ASHTON GRAYBIEL, ROBERT S. KENNEDY, and ROBERT S. KELLOGG, U. S. Naval School of Aviation Medicine, Pensacola, Florida, and Wright-Patterson AFB, Ohio.

The chief purpose of this investigation was to demonstrate the susceptibility of human subjects to canal sickness when stimulation to other gravireceptors including the otolith apparatus was minimized during parabolic flight. The experiments were carried out in a jet aircraft (USAF KC-135) specifically modified and manned for experimentation under weightless conditions. During the weightless phase of each parabola, approximately twenty-four seconds, the subject, while rotating in a motor-driven Barany chair at 30 RPM, was required to move the head in a prescribed fashion out of the plane of his bodily rotation. Each subject was exposed to ten such trials unless interdicted by the symptomatology. Twenty-three subjects were selected and categorized on the basis of their known or predicted insusceptibility to sickness during parabolic flights. A previously devised method was used of grading the symtomatology into five categories; sick (and vomited), S (v); sick, S; slight, moderate or severe malaise, M I, M II, M III respectively. Three subjects with bilateral labyrinthine defects did not manifest any symptoms during either control (no rotation) or experimental trials. The following symptomatology was manifested by the twenty normal subjects: S (v), 6; S, 5; M III, 2; M II, 3; M I, 3; Nil, 1. Thirteen of the twenty did not complete the ten experimental trials in the Barany chair, and it is noteworthy that they tended to recover from their symptoms during the remaining portion of the flight. Two conclusions were reached; firstly, that some subjects exposed to Coriolis force in parabolic flight readily became sick and secondly, that a new procedure has been devised for extending useful experimentation in weightlessness. This research was conducted jointly by the Naval School of Aviation Medicine and the Human Engineer Branch, Wright-Patterson Air Force Base, under the sponsorship of the Office of Life Science Programs, National Aeronautics and Space Administration.

Effect of Magnetic Fields on the Growth of Algae. MYRON H. HALPERN and JOHN J. KONIKOFF, Space Sciences Laboratory, General Electric Company, Philadelphia, Pennsylvania.

The use of high magnetic fields has been considered for shielding against radiation of space. Since such fields are considerably higher than Earth's 0.5 gauss, the question arises as to their effect on biological material in such a shielded space vehicle. Because algal systems may form part of a vehicle's life support system, *Chlorella pyrenoidosa* was selected for study. Cultures were submitted to magnetic fields of 750, 1,000, 4,000, and 20,000 gauss for periods of up to seven days. Daily readings of culture density were made with a Klett-Summerson Photocolorimeter. Based on over 60 experimental and 50 control cultures, data show that growth effects varied with the magnetic field from inhibition to marked acceleration. In all fields, no significant change occurred until the third to fourth day. The 750 gauss and the 1,000 gauss fields showed little growth effect. By the seventh day, some modification of growth over the control cultures was observed, but was not significant. However, the 4,000 and 20,000 gauss fields showed the most dramatic acceleration in growth rate. By day seven, the 4,000 gauss cultures exhibited a 106 per cent growth increase over the controls, and the 20,000 gauss cultures a 138 per cent increase in growth over the controls. These data indicate that high magnetic fields hasten the growth rate of algae. This finding may be of considerable significance for increasing algal yield in the algae-based life support systems.

Effects of Total Body Water Immersion on Weight Discrimination. THOMAS D. HANNA, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

It was hypothesized that motor performance involving the musculoskeletal system is impeded by the normal 1G environment. By considering the arms as relatively weightless when underwater, totally submerged subjects participated in a weight discrimination task. By securing various weight levels to one or both arms, the effects of several G loadings, i.e., forces acting on the arms toward the center of the earth, were explored. By the method of constant stimuli, it was found that the ability to discriminate differences in weights was greater with submerged subjects in 7 out of 9 conditions. Significant differences among 18 conditions both in and out of the water are analyzed and discussed.

Problems Associated with Measurement of Acoustic Transients. GEORGE J. HARBOLD and RAYMOND L. TAPIE, Bio-Acoustics Division, Life Sciences Department, U. S. Naval Missile Center, Point Mugu, California.

Rapid advances in space technology have been accompanied

by increasing noise hazards resulting from launching activities. Foremost among the problems of relating acoustic stimulation to human exposure is the accurate quantification of rise times, peak pressure levels and decay patterns of impulse-type noise.

The literature dealing with measurement of gunfire, blast, shock-wave, over-pressure, etc., indicates conventional acceptance and use of laboratory quality microphones, tape recorders, level recorders, impact noise analyzers and similar equipment. Evaluation of these types of systems by this laboratory has indicated serious limitations in response to acoustic transients, i.e., peak intensities of impulsive noise from small arms fire was found to be much greater than previously reported (24 db or 16 times the peak pressure). Also, measured values were not in accord with theoretical values.

In view of these limitations, a study was initiated to investigate the possibility of a system for impulsive noise measurement with extended transient response which would afford accuracy and flexibility necessary for field studies of a variety of weapons.

This paper constitutes a progress report of the effort to date. The limitations of conventional systems will be discussed. Pictorial evidence will be presented to illustrate the extent to which an extended transient response can overcome limitations of earlier systems.

Metabolic Rates in Pressurized Suits. THOMAS J. HARRINGTON, DAVID K. EDWARDS, and EDWARD C. WORTZ, AiResearch Manufacturing Company, The Garrett Corporation, Los Angeles, California.

The objectives of this study were to ascertain the metabolic rates of subjects wearing a prototype Project Apollo pressure suit and to verify the ability of the environmental control system to maintain a satisfactory heat balance. The experimentation was carried out in a high-altitude chamber at altitude equivalents of sea level and 34,000 feet, with the suit pressurized to 3.5 psi over chamber pressure. A variable speed treadmill was used to induce various metabolic rates in the subjects, and the physical characteristics of the suit inlet and outlet gases were monitored for temperature and water content. Metabolic rates were measured by partial pressure spirometry. The results indicate that the energy required to walk in the pressurized suit is at least 100 per cent higher than that required when the suit is unpressurized and that currently employed ventilation gas inlet characteristics are marginal for cooling purposes even at moderate work loads and completely inadequate for heavier work. The results also permit the formation of a tentative hypothesis (unconfirmed by this work) that altitude conditions with respect to suit ventilation could be adequately simulated at sea level by manipulating sensible heat removal.

Structural and Medical Analysis of a Civil Aircraft Accident. A. H. HASBROOK and J. R. DILLE, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

Results of an analysis of structural damage as related to fatal internal injuries sustained by a passenger in a survivable civil plane crash are reviewed; details on direction of crash force, the kinematics of the occupants and of the aircraft, and associated structural damage, are described. The possibility of obtaining incorrect conclusions as to the cause of fatal injuries in such accidents, unless minute and detailed analyses are conducted, is discussed. Photographs, medical details and diagrams are included.

Study of Electroencephalographic Changes amongst Egyptian Air Pilots. MAHMOUND HASSANEIN, Cairo, Egypt.

As aviation becomes increasingly complex, new problems, affecting both men and machines, are brought sharply into focus. Foremost amongst these problems is flight safety. The role of the human element in the causation of accidents is frequently stressed and reports suggest that well over 50 per cent of accidents can be attributed to pilot failure. High performance aircraft have increased the fineness of judgment demanded of the pilot while at the same time the results of failure are more serious. Failure of pilot response may be due to any one of a variety of factors such as hyperventilation, vertigo, G forces, hypoxia, decompression and disorientation.

Alterations of the pilot's cerebral activity are of primary importance in this respect. It is known, for example, that frequent changes of atmospheric pressure or anoxia may increase EEG abnormalities. It is important to study the cerebral activity of pilots in order to determine if factors exist which might make any given man less efficient or even accident prone.

The aim of this study is to establish the range of variability of the alpha rhythm of EEG records of a selected group of normal Egyptian pilots and to attempt to classify the records into groups, each with its own characteristics. Such a classification might be useful in choosing the type of person most capable of withstanding the various environmental stresses of high altitude flying without deterioration of his alertness.

Biochemical Measure of Impact Stress in Chimpanzees. E. J. HAWRYLEWICZ and W. H. BLAIR, Illinois Institute of Technology Research Institute, Chicago, Illinois.

This study was undertaken to determine whether a biochemical index could be established which relates impact velocity to tissue damage. Serum samples were taken from six chimpanzees before and 1 hr. 24 hr., and 1 wk. after an impact test (sled ride). The serum samples were frozen immediately and subsequently analyzed for lactic acid dehydrogenase (LDH) activity and LDH isoenzyme patterns.

A direct relationship was demonstrated between impact velocity, G load on the subject and its LDH serum level. The enzyme level changes were transitory, returning to a value near normal 1 wk. after the impact test.

Each LDH serum sample was resolved into its LDH isoenzyme patterns. The electrophoretic band patterns illustrated marked alterations, which were related to the velocity of impact. The electrophoretic components were resolved by a new technique, which permits eight samples to be resolved in 40 minutes.

The relationship between total serum enzyme levels and impact stress is not unique. A number of environmental stresses increase serum LDH. The unique aspects are the method of resolution of the LDH enzyme into its isoenzyme patterns and the effect of impact stress on the patterns. The data suggest the possibility of relating the severity of impact stress to isoenzyme pattern changes.

In order to correlate the changes produced in LDH isoenzyme patterns by a stressed organ, pathology will be related to pattern changes.

Physiologic Response to Increased Oxygen Partial Pressure: Clinical Observations. JAMES E. HERLOCHER, DAVID G. QUIGLEY, E. G. SHAW and BILLY E. WELCH, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The need for more definite information concerning the physiologic effects of prolonged exposure to increased partial pressures of oxygen has been the subject of great debate in the selection of spacecraft atmosphere. As mission duration lengthens the need to define accurately the atmosphere requirements of man will become more critical and it will be necessary to study physiologic responses in an environment closely simulating that of the spacecraft under consideration. The experiments reported here were designed to study the effects of oxygen concentrations producing an alveolar oxygen partial pressure of approximately 175 mm. Hg, i.e., that contemplated in the Gemini and Apollo spacecraft. Twelve subjects, selected from a pool of volunteer airmen at Lackland Air Force Base, Texas, were divided into three groups of four men each. Four were exposed to an oxygen-nitrogen atmosphere containing 33.3 per cent oxygen at a total pressure of 700 mm. Hg; four were exposed to an oxygen atmosphere (approximately 98-99 per cent on a dry gas basis) at a total pressure of 258 mm. Hg; two subjects were maintained as ambient controls during each experiment. Each experiment of 42 days duration provided 7 days control, 30 days in the experimental atmosphere, and 5 days followup. Observations included subjective responses, objective clinical findings, routine blood and urinary studies and dark adaptation using a Goldman-Weekers dark adaptometer. The results of these studies are considered in relationship to the atmosphere selection programs of current and future spacecraft.

Subcellular Mechanisms and Biophysical Indicators of Radiation Induced Injury. PHILIP B. HOLLANDER, Astro-Electronics Division, Radio Corporation of America, Princeton, New Jersey.

Radiobiologists have been concerned for more than 60 years with the mechanisms by which absorbed radiation energy alters cellular activities. Biochemical lesions caused by the transfer of ionizing radiation energies to molecular bond(s) energy result in the production of substances like protoplasmic poison(s) which may be potentiated by subsequent molecular derangement, energy transfer to other molecules, or free radical formation. It has been amply demonstrated that all cells can be insulated by ionizing radiation in a manner similar to protoplasmic poisoning and the end results are widely distributed in both time and observable effect. At the present time there is no real-time method, either physical or biological, to determine how much radiation energy has been absorbed by the organism. Physical dosimeters and some tissue specimens or fungi have been used to determine the applied dose of absorbed dose of irradiation, but these methods yield results after the fact or in lapsed-time.

Recent work has shown that mammals respond to small doses of irradiation by operant behavioral changes (0.0007 r/sec.) conditioned response changes (0.050 r/sec.), changes in functional properties of nerves (17 ergs/mm.^{2}), electroencephalographic desynchronization or animal arousal (0.2 r/sec.), and elicitation of the B-wave of the electroretinogram (6.5 r/sec.). Detection of irradiation at the lower limits would afford at least a minimum lead time to initiate prophylactic measures before tissue damage could occur. Appropriate biophysical sensors would not only provide a real-time absorbed-dose irradiation indicator, but also indicate any tissue trauma which would incapacitate the subject.

Study of Massive Gastrointestinal Hemorrhage in Flying Personnel. DUDLEY B. HOULE, HOWARD R. UNGER, PAULL R. HANSON, and ALONZO T. TOWNER, Headquarters, USAF, Strategic Air Command, Offutt AFB, Nebraska.

Over three hundred cases of massive gastrointestinal hemorrhage in SAC flying personnel were reviewed and analyzed for diagnosis, therapy, and results.

The largest group in this series is composed of individuals who have suffered one or more episodes of bleeding from a peptic ulcer. Bleeding as a result of peptic ulcer disease makes a return to flying status a complicated procedure and demands the ultimate in judgment during aeromedical evaluation. The material contained in the body of the paper will summarize the experience of SAC in this entity and provide the flight surgeon with more information to guide his judgment in dealing with similar cases.

Surgical and nonsurgical therapy and results will be discussed. Comments will include opinions regarding surgical procedures such as gastric resection and plyloroplasty with vagotomy.

The Telemetered Electrocardiogram in Clinical Cardiac Diagnosis. ROBERT L. JOHNSON, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Telemetry technics used for remote electrocardiographic monitoring during aircraft and space flight have found increasing application to clinical cardiac diagnosis. Using similar criteria for positive responses, the telemetered ECG during exercise shows significant ST segment and T wave changes more often than the post-exercise electrocardiogram of the two-step exercise test. That these changes indicate coronary disease is not yet established.

Utilizing strict criteria, positive responses to the double Master two-step test have been distinctly rare among Air Force flying personnel. Experience at the School of Aerospace Medicine with telemetered exercise electrocardiograms and double Master two-step exercise tests in over 500 fliers without clinical coronary disease indicates that electrocardiographic changes during exercise must be interpreted with even greater conservatism to avoid false-positive diagnoses. Comparison of conventional leads and telemetered leads, taken simultaneously after severe exercise, documents the fact that the bipolar chest leads commonly employed for the telemetered electrocardiogram are inherently subject to greater physiologic variation than the standard limb and unipolar limb leads. An appreciation of these variations in apparently healthy individuals, with emphasis upon ST and T wave changes and occasionally arrhythmias seen during exercise, is essential to valid interpretation of the telemetered electrocardiogram both in clinical and in remote monitoring situations.

Dominance of Anti-Compensatory Oculomotor Response during Rapid Head Rotation. G. MELVILL JONES, Department of Physiology, McGill University, Montreal, Canada.

Smooth rotation of the head is normally accompanied by an oculomotor response comprising smooth, slow-phase, compensatory eye movements interspersed with quick, anti-compensatory flicks which reposition the eyes and ensure that they operate more or less over their mid-range of movement in the orbit. Experiments with human subjects have shown, however, that when the head is jerked with a high angular velocity, say to the right, an unusually large anti-compensatory flick drives the eyes hard over in the leading direction, in this case to the right, where they remain until the head slows down. Then the expected compensatory response to the left begins to appear. If the high head angular velocity is artifically maintained, as on a turntable, the expected compensatory response may be completely inhibited for several seconds, presumably owing to prolonged action of a strongly maintained anti-compensatory response. This phenomenon can occur in the rolling plane and has been demonstrated during flight in the initial stages of a rapid rolling maneuver. Presumably consequent failure of retinal image stabilization could cause serious impairment of visual acuity at this critical juncture. The fact that exclusion of vision and neck proprioception do not prevent dominance of the anti-compensatory response, points to a vestibular cause. This in turn, suggests that vestibular signals can exercise a substantial measure of control over the quick, anti-compensatory phase of nystagmus.

Mechanisms of Hemolysis Induced by Hyperoxia. HERBERT E. KANN, CHARLES E. MENGEL, ALVIN M. LEWIS, and BETTY HORTON, Department of Medicine, Duke University, Durham, North Carolina.

The hemolytic anemia that occurred in normal subjects exposed for 48 hours to 100 per cent oxygen at a total pressure of 7.4 psi was apparently caused by the increased partial pressure of oxygen. This problem might be avoided if the biochemical basis of the hemolytic process were understood.

We have studied erythrocytes of patients and volunteers who were exposed to 100 per cent oxygen at a total pressure of 45 psi (OHP) for changes in: 1) Routine hematologic indices, 2) Oxidation-reduction transformation components, (catalase, reduced glutathione, glucose-p-phosphate dehydrogenase), 3) Phosphorylated glycolytic intermediates, 4) Hemolysis and lipid peroxide levels after exposure to *in vitro* oxidant stresses.

Erythrocytes of six subjects who were exposed to OHP for thirty minutes showed exaggerated autohemolysis, suggesting glycolytic abnormalities. Erythrocytes of two patients who were exposed to OHP for eight and ten hours showed decreased levels of adenosine tri-phosphate and increased levels of adenosine di-phosphate, inorganic phosphorous, (and fructose-1, 6-diphosphate in one).

These data implicate abnormal glycolysis in hyperoxic hemolysis. Earlier studies in this laboratory suggested a role of abnormal lipid peroxidation. These two phenomena may be related, with peroxidation of erythrocyte stromal lipid being the primary reaction, the products of which, through their known ability to inactivate sulfhydryl-bearing enzymes, secondarily cause glycolytic failure. If this is so, hyperoxic hemolysis is avoidable, since abnormal lipid peroxidation, the postulated primary biochemical event, could be prevented by a variety of antioxidants.

The Reliability of the Electrical Impedance Pneumograph for long Term Monitoring of Respiratory Function. GALE H. KAPLAN, Holloman AFB, New Mexico.

There is a requirement for a respiration sensing system that will provide accurate quantitative measurement of tidal volume and respiratory rate. The system must be accurate, have long term stability, augment and be compatible with other measurements

and be physiologically acceptable to the subject. The impedance pneumograph appears to meet these requirements.

At the 6571st Aeromedical Research Laboratory respiratory function has been measured with heated thermistors, strain gage flow meters, fluid filled stretch sensitive rubber tubes, spirometers, and the electrical impedance pneumograph. The impedance pneumograph has been compared in performance for long term monitoring with these devices. Details of the comparison and conclusions are presented.

A problem observed with the impedance pneumograph was the lack of long term stability. After being attached to the subject and adjusted, it will give a usable signal for a matter of minutes. Then, when long term (one day or longer) measurements are attempted base line shifts cause the signal being recorded to limit. For satisfactory data the pneumograph or recording devices must be readjusted. Necessity to readjust may be due to movement artifact, faulty electrodes, or a real change in rate and tidal volume.

In many cases very unnatural conditions exist during this laboratory's attempts to measure respiratory activity. Human subjects can readily cooperate but chimpanzees under restraint add a factor that directly affects respiratory measurement. Other problems with the impedance pneumograph include calibration for tidal volume and cost.

Skin Temperature Responses to Optically Filtered Intense Thermal Radiation. W. C. KAUFMAN and J. C. PITTMAN, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The irradiance and spectral characteristics of the radiant energy from tungsten filament quartz lamps allow laboratory research on the temperature responses of human skin to thermal radiation of the type produced by intense fires or nuclear explosion. Skin temperature changes of the dorsum of the hands of 6 subjects were measured radiometrically during intense thermal radiation in 125 experiments. Irradiance levels ranged from 0.06 to 0.6 cal/cm.^{2} • sec. Energy was unfiltered, filtered by plexiglass, or filtered by laminated plate glass (aircraft windshield). Laminated glass showed the greatest attenuation, allowing only ¼ the temperature change produced by unfiltered energy. Plexiglass attenuated the skin temperature response by 2/3. With equal irradiance, measured at the skin, plexiglass provided significant attenuation when compared to unfiltered energy and laminated glass provided significant attenuation when compared to plexiglass. These differences are due to the interrelation of spectral characteristics of the filtered radiant energy and human skin. The attenuation provided by various optical filters has extensive civil defense, firefighting and military application. These data also show that some discrepancies appearing in the literature arise from the use of energy sources of different spectral characteristics. Only ½ the temperature change resulting from exposure to the unfiltered energy occurs in response to an equal amount of plexiglass filtered energy.

Movement of Respired Gas in Manned Space Enclosures. D. A. KEATING, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Advanced theoretical and experimental analyses of the movement of respired gas in manned space enclosures under the influence of weightlessness and reduced gravity are considered.

The theoretical analysis considers an astronaut in infinite and space enclosures. The exhaled gas is considered to be injected infinite to the space enclosure as a pulsating jet from an instantaneous source and from a continuous source. The viscosity of the surrounding fluid slows the exhaled gas until the only means of gas dispersion is due to molecular diffusion. The exhaled gas is considered to be divided into two portions which emanate from the nostrils. The amount of carbon dioxide which is inhaled is dependent upon the position of the previous exhalations due to momentum and viscosity, and upon the dispersion due to diffusion.

The experimental analysis is an evaluation and verification of the theoretical analysis and considers manned, small animal, and non-biological experimentation. Each phase of the experimentation is complementary unto the other phases. This experimentation has been performed in the earth laboratory as well as under the actual conditions of reduced gravity and weightlessness. The modified USAF KC-135 aircraft and dimensional analysis and similitude model techniques have been used as the primary methods of experimentation.

The theoretical and experimental analyses have been integrated to thoroughly investigate the minimal atmosphere movement required for life support during manned space flight. The results presented in this paper are basic fundamentals of manned space flight technology.

The Role of Feedback in Adaptive Perceptual Process. R. A. KINCHLA and R. C. ATKINSON, NASA-Ames Research Center, Moffett Field, California, and Stanford University, Palo Alto, California.

This paper deals with the analysis of an observer's performance on tasks involving partially discriminable stimuli. Two variations of the task are considered: information feedback and no information feedback. In the feedback situation the observer obtains information concerning the correctness of his responses, whereas in the no feedback situation he does not. A mathematical theory of the discrimination process will be introduced that, in contrast to previous theories, provides an analysis of sequential effects observed in discrimination data. These effects are treated as the product of an adaptive perceptual process. This process tends to optimize an observer's operating characteristic in relation to the stimulus distribution. Two acoustical discrimination experiments were conducted to evaluate the role of feedback in this adaptive process. In all, 26 subjects were run for 21 days under different conditions of feedback and stimulus distribution. Data from these experiments will be presented and evaluated in terms of the theory. The results indicate how feedback accelerates the adaptive process and amplifies sequential effects. While the research is directly related to the measurement of sensory capacities, it has implications for any situation in which an observer is asked to make fine discriminations.

Early Diagnosis of Cardiovascular Disease amongst Aircrew. H. W. KIRCHHOFF and E. A. LAUSCHNER, Institute of Aviation Medicine, German Air Force, Furstenfeldtbruck, Germany.

The incidence in cardiovascular disease amongst aging aircrew is steadily increasing and requires the development of more specialized test methods with the aim of obtaining an earlier diagnosis. Some test combinations have given satisfaction to the German Air Force Institute of Aviation Medicine. They seem to be able to broaden the diagnostic possibilities as far as functional margins and cardiovascular economy are concerned and seem to be useful as a basis for preventive and rehabilitating measures.

A rather complex cardiovascular evaluation seems to give useful information on regulative mechanisms of several functional complexes. In evaluating comparatively the most important existing parameters further information is obtained on cardiovascular workload and economy as well as functional regulations and their limits. These parameters are: oxygen intake, carbon dioxide output, respiratory quotient, respiratory minute volume, respiratory equivalent, pulse rate, arterial tension, oxygen pulse, ECG in 12 channels, EEG and peripheral oxygen saturation. Nearly all values are obtained both on rest and after a determined ergometric effort.

It is hoped that this complex investigation allows an early diagnosis of functional disturbances and beginning of cardiovascular disease at a moment, where adequate treatment may be capable—in many cases—not only to reduce the functional limitations and to increase the cardiovascular efficiency but also to maintain or restore the capability for military flying. The treatment consists of a combination of adequate diet, physiotherapeutic measures and required medication, steadily increasing active physical training is given an important place in this therapeutic complex.

Effects of Very High Magnetic Fields on Living Organisms. JAMES C. KNEPTON and DIETRICH E. BEISCHER, U. S. Naval School of Aviation Medicine, Pensacola, Florida.

Magnetic fields are being considered in a number of future constructions of manned spacecraft, while environmental effects

of such fields on living matter have not found corresponding interest. The report describes exposure of a variety of biological material to magnetic fields of extremely high strength reaching 140,000 gauss. Such fields did not influence the luminosity of *Photobacterium fischeri*, the mutant rate of *Neurospora crassa*, different exposed stages of the life cycle of *Drosophila*, or mouse activity. However, magnetic fields of 140,000 gauss reduced the rate of cell division of fertilized *Arbacia* eggs in the first stages of development, and fields of 70,000 gauss had a noticeable cardiac effect on squirrel monkeys. These observations are of great interest for the planned exposure of man to strong magnetic fields.

Value of Radioelectrocardiography during the Double Master 2-Step Test Compared with the Standard Post-Exercise Electrocardiogram. DONALD M. KNOWLAN, RUTH A. WEINMANN, and IRWIN H. ARDAM, Federal Aviation Agency's Georgetown Clinical Research Institute, and Department of Medicine, Georgetown University Hospital, Washington, D. C.

Radiotelemetering of the electrocardiogram *during* the performance of the Standard Double Master 2-Step Test is reported to significantly increase the number of the positive responses to the test. The radioelectrocardiogram (RKG) was obtained during and after the Double Master 2-Step Test in 221 males and compared with the standard post-exercise electrocardiogram (ECG) taken simultaneously. In 54 individuals with positive post-exercise electrocardiograms, the RKG was positive in 29. The RKG was positive in only two individuals among the 167 with a normal post-exercise electrocardiogram.

In the group (31) with a positive response recorded on the RKG, the change was noted during exercise in 70 per cent. The RKG detected 43 incidences of arrhythmias (predominately premature ventricular contractions) and conduction disturbances during exercise that were present in only nine post-exercise electrocardiograms. In two cases of W.P.W., the RKG recorded positive exercise responses with change in position.

The RKG, limited by its single lead (V5) system, did not increase the yield of positive responses to the Double Master 2-Step Test. It is of particular value in detecting arrhythmias and conduction disturbances that occur during exercise, and at times, may reveal positive responses before the standard method, allowing an earlier termination of the exercise. Perhaps a newly designed multi-lead system that can record during exercise will obviate some of the limitations.

Observations on Acute and Chronic Oxygen Poisoning. GEORGE H. KYDD and LOUIS H. BETZ, Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania.

Some rats repeatedly exposed to oxygen at high pressures (OHP) develop a permanent paralysis that affects principally the forelegs but which may affect large parts of the body. These effects have been called chronic after effects or oxygen paralysis. Apparently all rats can be made to show the well-known neuromuscular signs including convulsions which are called acute effects and which are observed whether or not paralysis develops. In an effort to discover a relationship between the occurrence of convulsions and paralysis, susceptible rats have been repeatedly exposed to OHP under conditions that would tend to lessen the occurrence of convulsions. One group was lightly anesthetized (10 mg./kg. Nembutal) and the other exposed for a short time and decompressed very slowly. Two anesthetized animals developed paralysis without having exhibited any previous acute (convulsive) effects. Four other anesthetized animals developed paralysis with only slight acute effects. All of the slowly decompressed animals convulsed and only two of these showed paralysis. These observations indicate that paralysis and convulsions are not necessarily associated symptoms of oxygen toxicity.

Principles and Methods for Using Electroencephalography in Aviation Medicine. EUGENE LAFONTAINE, CLAUDE J. BLANC, and ROBERT LAPLANE, Central Medical Service of the Compagnie Nationale Air France, Paris, France.

In this work, the authors give an account of the latest developments in their research on the meaning of data provided by electroencephalography in aviation medicine. This is based on a documentation comprizing 10,000 graphs arranged in evolutive studies spread over periods of five to ten years. The clinical, psychological and bioelectric data examined in these studies led to the readjustment of selection standards which were initially borrowed from the neurology EEG critera. The interest of EEG, primarily directed towards the detection of epilepsy and after effects of organic brain injuries, gradually shifted to the study of general psychological, psychiatrical and physiological factors. If the confrontation of EEG data and psychometrical tests have proved negative for most of the authors who used them, the electrical and psychobiological evolutive studies show definite correlations between certain types of EEG organization and, the neurotic and depressive predispositions of the personality (psychoelectric decompensation syndrome).

The hiring and surveillance standards of the technical and commercial flying staff are presented. They have been significantly altered, in comparison to what they were ten years ago. This liberalization is conditional and counter-balanced by a re-enforcement of EEG and psychobiological measures of surveillance. The conventional neurology EEG criteria are still used when there are antecedents or when a clinical context is present—particularly in the case of brain trauma.

The authors think it advisable to generalize in the future the use of a hiring EEG examination for applicants to technical airman duties in all airlines. This document is an important reference in the records for ulterior pathological cases and in particular brain trauma.

Electroencephalography does not constitute in itself a technique for selection on the simple basis of affirmative or negative answers to the problem of aptitude. It actually represents a satellite method of neuro-psychological or psychiatric selection. Thus conceived and integrated, it has proved in practice most useful. The rapid development of aeronautic techniques cannot but increase its importance in years to come.

Visual Changes Observed in the Manned Revolving Space Station Simulator at High Rotational Speeds. J. M. LAGERWERFF and BERNARD D. NEWSOM, General Dynamics/Astronautics, San Diego, California.

For the purpose of studying man's rotation tolerance and performance under conditions resembling those expected to exist in certain space operations, a 220,000 g-pounds capacity centrifuge was converted into a Manned Revolving Space Station Simulator. A 14 x 8 x 7 foot trunnioned room was mounted at a 20 foot radius on the centrifuge arm. This room is completely furnished to enable six persons to remain on board for several weeks.

Twenty volunteer subjects were exposed to rotations at 5, 7.5 and 10 RPM for a total of three hours, for the specific purpose of determining visual changes as a result of rotational stress and Coriolis accelerations. The subjects moved around freely in the "space station" during rotation.

Five vision test batteries, each consisting of eleven separate tests, were administered at one hour intervals as follows: One before rotation; one during each of the three rotational velocities; and one after the centrifuge had stopped.

Appreciable changes were found in the lateral and vertical phorias, macular stereopsis, power of divergence and convergence, complex spatial perceptive capability, and peripheral vision of the majority of the subjects. Three distinct "reaction patterns" could be distinguished in the refraction tests.

Pathology and Physiology of Guinea Pigs under Selected Conditions of Impact. CHARLES F. LOMBARD, S. DAVIS BRONSON, FREDERICK C. THIEDE, and PERRY CLOSE, Northrop Space Laboratories, Hawthorne, California.

Guinea pigs have been exposed to impacts under selected conditions of support and restraint. Variables included orientation of the body to the line of force, contouring of the restraint container and various types of support-restraint materials.

The effects of the impacts were evaluated by the comparison of both physiological and pathological data. Selected cardiovascular and respiratory measurements were obtained on animals both before and after the exposures. Internal pressure measurements were obtained in some cases. Gross and micropathology was determined by conventional methods and by the employment of vital dyes. Some insight into the mechanisms of lethal cerebral injury has been obtained.

The results indicate that while remarkable tolerances have been observed under ideal laboratory situations, attention must be given to support-restraint design compatible with operational requirements. Particular consideration must be given to the prevention of rebound as may occur from a loose harness. Acceleration inputs were 230 G or more, at onset rates of 100,000 g/sec. and greater. Velocities at impact were 45 to 50 ft./sec.

Water Potability Problems in Manned Spacecraft. G. A. LORENZEN and NANCY WHITECOTTON, NASA Manned Spacecraft Center, Houston, Texas.

As the duration of man's flight into space increase the problem of supplying him with water becomes more acute. Weight and space requirements limit the amount that can be carried. Thus, obtaining water as a by-product of other essential activities becomes not only attractive but practical.

Two sources of water are being considered. The first, fuel cell water, which is obtained as a by-product of power production by elemental hydrogen and oxygen. The second source is condensate water obtained by condensation of sensible and insensible body water losses in the environmental control system.

The problem of establishing potability of this water differs from that of normal drinking water. Although the United States Public Health Service standards are adequate for most purposes, many of the requirements are not necessarily applicable to the space vehicle. First, the duration of the mission may allow higher consumption of contaminants for shorter periods of time without deleterious effects. An example of this would be hexavalent chromium. Secondly, the question of bacteriological contamination of drinking water must also be considered. Public Health Service standards are primarily concerned with fecal contamination of the drinking water and E. coli is used as an indicator organism. The problem of fecal contamination does not arise in the space vehicle. However, the nature of the contamination which may exist, and the question of whether any contamination at all can be tolerated is presented.

Airborne Transmission of Infection in Low Gravitational Fields. ROBERT G. LOUDON, University of Texas Southwestern Medical School, Dallas, Texas.

Two factors limit the aerial transmission of infection. One is fall-out of the larger droplets due to gravity; the other is atmospheric dilution of the remaining smaller droplet nuclei. In spite of these limiting factors, the aerial route is most important in the transfer of microorganisms from person to person. Both of these limiting factors, gravitational fall-out and atmospheric dilution, are drastically reduced in space.

During activities such as coughing or talking, large numbers of droplets are expelled from the respiratory tract. Droplets of less than one hundred microns in original diameter may evaporate down to droplet nuclei of ten microns or less and remain airborne for hours or days. In the terrestrial gravitational field, droplets larger than this are scavenged by gravity. These larger droplets contain the majority of expelled microorganisms. The effect of reduction in gravity upon the duration of aerial suspension of droplets and droplet nuclei of various sizes will be discussed.

The numbers of droplets of different sizes produced by various activities have been measured, using a new technique. Respiratory maneuvers are conducted into an atmosphere enclosure previously purged by laminar filtered air flow. Droplets and droplet nuclei are recovered from the enclosure and impacted on a surface of chloride-free agar gel, containing silver nitrate. They are measured and counted under incident light microscopy.

The effect of reduction in the gravitational field on the aerial transmission of infection will be discussed, as will the results of increased interchange of organisms. These factors must be considered when space flight involves more than one person; possible approaches to atmospheric hygiene will be outlined.

Utilization of Urinary Nitrogen Compounds by Chlorella Pyrenoidosa. VICTORIA H. LYNCH, ELIZABETH C. AMMANN, and ROGENE M. GODDING, Lockheed Missiles and Space Company, Palo Alto, California.

Unicellular green algae have been considered as one component of a biological regenerative environmental control system. The continued synthesis of new algal cell material requires an available supply of nitrogen. The nitrogen waste products of man, found primarily in urine, would be the source of nitrogen in a space system. The nitrogen nutrition of the algal cells will influence their composition and their nutritive value for man.

The ability of individual urinary nitrogen compounds to support growth of *Chlorella pyrenoidosa* has been investigated. The amount of cell growth, growth rates and degree of utilization of each nitrogen compound has been determined. All experiments were performed under sterile conditions and checked at each sampling for bacterial contamination.

Urea, ammonia, guanine, adenine, xanthine, hypoxanthine, uric acid, glycine, l-alanine, l-serine, l-glutamine, l-aspartic acid, l-asparagine, l-arginine, l-orinthine and l-citrulline support growth, and are completely decomposed. Alantoin, creatinine, hipuric acid, $_{\beta}$alanine, $_{\alpha}$amino butyric acid, norvaline, l-valine, l-leucine, l-isoleucine, l-lysine, l-phenylalanine, l-tyrosine, l-tryptophane, l-histidine, l-cysteine and l-glutamic acid do not support growth, and are not utilized.

The nitrogen content of an algal cell can be modified by its growth environment. The effect of this change in composition on oxygen production and protein composition of the algal cells will be discussed.

Visual Studies of Indirect Viewing and Vigilance under Normal Atmospheric Conditions. NORMAN H. MACKWORTH and Ross A. MCFARLAND, The Guggenheim Center, Aerospace Health and Safety, Harvard School of Public Health, Boston, Massachusetts.

In aerospace research there is a great need for good measures of impaired visual performance. These yardsticks are required for many different purposes related to equipment design especially in panel layout. Similarly the technique is of value in determining training requirements for visual tasks as widely different as those undertaken by astronauts and radiologists. These measures will also be useful in attempts to set the desirable limits for atmospheric condition by experimental studies of human achievement. They may also be of value in appraising changes with age and brain damage.

One way of discovering reliable techniques is to use the eye-camera devices that have recently become available to record the position of the line of sight.

A laboratory or bench mounted eye-camera has given data on indirect or peripheral viewing. This provides base-line information on the size of the field of view around the fixation point during certain standard visual tasks. This analysis if the width of the scene encompassed by individual glances is intended as a first step towards discovering whether there is any sign of the effective field of view becoming restricted when, for example, the subjects are working at high altitude or in heated environments.

A new miniature eye camera mounted on a head band has also been devised to record via a fiber optics system. This allows the subject to move his head freely and therefore, has a special place in the analysis of visual scanning during prolonged visual search. Evidence will be presented on attempts to measure alertness under normal conditions by recording the incidence of looking without comprehension, since such lapses in attention are clearly of importance in trying to understand the reasons for failures in visual monitoring.

Measurements Required for a Manned Earth Orbiting Space Station. C. J. MARTELL, G. A. ALBRIGHT, and W. M. HELVEY, Spacelabs, Inc., Van Nuys, California, Republic Aviation Corporation, Farmingdale, New York, and Lockheed Missiles and Space Company, Sunnyvale, California.

This paper will present some of the results of a study on the Biomedical and Human Factors Requirements for a Manned Earth Orbiting Station. The primary objective of the study was to determine which measurements must be made on board a space station to assure adequate evaluation of the astronaut's health and performance during prolonged space flights. The study employed a medical and engineering systems analysis to define the pertinent life sciences and space station design parameters and their influence on a measurement program. The known or

anticipated effects of such environmental factors as weightlessness, acceleration, radiation, and cabin atmospheres on major bodily functions as mental performance, circulation, fluid and electrolyte balance, and musculoskeletal integrity were assessed. The medical importance of measuring such responses, and the required instrumentation facilities to obtain such data were defined. Measures were selected as required for safety of flight and to determine any significant effects of prolonged space flight on the crew. These will be described as well as space vehicle biomedical facilities in which such examinations, measurements, and laboratory tests could be conducted.

Oxygen Toxicity and Vitamin E. C. E. MENGEL, H. KANN WIRT SMITH and B. HORTON, Department of Medicine, Duke University Medical Center, Durham, North Carolina.

Previous studies of CNS oxygen toxicity revealed great variability in response of animals of the same strain obtained from different sources. It was concluded that some unknown factor, possibly dietary, might have been responsible. We have been studying the effects of *in vivo* hyperbaric oxygenation (OHP) (100 per cent oxygen at 30 to 75 psia for varying periods of time) on mouse erythrocytes. Vitamin E deficient mice (whose erythrocytes are unusually sensitive to *in vitro* oxidant stresses and from high levels of lipid peroxides) have developed hemolysis (hemoglobinemia and reticulocytosis) after *in vivo* OHP. These changes *(in vivo* and *in vitro)* were prevented by the prior administration of α tocopherol. During these studies it was noted that vitamin E supplemented mice tolerated OHP for longer periods before developing convulsions than Purina Chow fed and vitamin E deficient mice. These studies illustrate similarities in the prevention of erythrocyte and CNS oxygen toxicity by vitamin E suggest a common mechanism for both. The mechanism may be related to abnormal production or destruction of lipid peroxides.

Radiobiological Effects of Incompletely Penetrating Electron Radiation. O. M. MEREDITH, E. G. BOWERS, and J. T. HEINTZELMAN, Lockheed Missiles and Space Company, Palo Alto, California.

While extreme radiobiological effects are certain with high energy solar flare protons, the injury potential of weakly penetrating electrons to the mammalian system should not be underestimated. Whole body exposure to such electrons can result in lethal action dependent upon the amount of surface area radiated as well as the anatomical region. One Mev electrons, generated with a resonant transformer apparatus and having a mean range of 0.5 cm. in water, were beamed upon either the abdominal or dorsal aspects of anesthetized CF_1 mice at a rate of 3000 rads per minute. Subsequent observations indicated entirely different patterns of injury for irradiation of the abdomen or back. For example, 1500 rads delivered ventrally caused alterations in the visceral weights and blood count, while the mean survival time was 6-8 days. Fatal effects were reduced if only one-half of the abdomen was irradiated. A similar irradiation of the back caused deaths only after 12-14 days when severe burns developed without significant effects upon the viscera. These results indicate a particular need for protection of the abdomen during heavy electron exposures which might occur in an earth radiation belt or with secondary electrons produced by heavy particles interacting with shielding materials.

Hematologic Effects of Microwave Irradiation. SOL. M. MICHAELSON, RODERICK A. E. THOMSON, M. Y. EL TAMAMI, and JOE W. HOWLAND, Department of Radiation Biology, University of Rochester School of Medicine and Dentistry, Rochester, New York, and Griffiss AFB, Rome, New York.

Reports in the past have indicated nonspecific hematologic changes among persons occupationally exposed to radar. Most of the hematologic studies on animals exposed to microwaves have been limited to observations in rodents. Systematic study of the effects of microwaves in the dog is relatively .rare although this animal has a hematologic system much more comparable to man than do rodents. Whole body exposure of normal dogs to microwaves results in leukocyte changes which can be related to frequency, field intensity, and duration of exposure. A marked decrease in lymphocytes and eosinophils occurs after six hours of 100 mw/cm.^{2}, 2800 Mcycles/sec. (pulsed) microwave exposure with a mean rectal temperature increase of 1.8°F. Neutrophils are slightly increased at 24 hours while eosinophils and lymphocytes have returned to normal levels at this time. After two hours of exposure to 165 mw/cm.^{2} with a resulsane 3°F. rise in rectal temperature there is a slight decrease of all white cells and a definite hemoconcentration. Eosinopenia is still evident twenty-four hours after exposure. Hematologic changes are more marked after three hours exposure to 165 mw/cm.^{2} Cr^{51}, and Fe^{59} studies indicate alteration of red blood cell life span and bone marrow function at these exposure levels. General leukocytic changes are more apparent after 1280 Mcyles/sec. pulsed and 200 Mcyles/sec. continuous microwave exposure. Simultaneous x-irradiation and microwave exposure results in accelerated recovery of the ionizing radiation induced neutropenia and prolongation of the lymphocytopenia. The results of these studies are indicative of hypothalamic and/or adrenal stimulation (stress effect) of microwave exposure and the biologic interaction of microwave and ionizing radiation energies.

Otolith Organ Activity within Earth Standard, One-Half Standard and Zero Gravity Environments. E. F. MILLER, II, A. GRAYBIEL, and R. S. KELLOGG, U. S. Naval School of Aviation Medicine, Pensacola, Florida, and Aerospace Medical Division, AFSC, USAF, Wright-Patterson AFB, Ohio.

Measurement of ocular counterrolling as a specific indicator of otolith activity provides a method of determining the functional level of this inner ear organ when its adequate stimulus (linear acceleration) is changed. Within a C131B aircraft six normal and six labyrinthine defective (L-D) subjects, forming a control group were placed by means of tilt-chair device at several tilt positions. In each of these body positions counterrolling response was recorded photographically at the end of the zero G and 0.5 G phase of a parabolic flight maneuver. Comparable measurements were also made under normal (1 G) conditions. The film recordings gathered from several hundred parabolas were then analyzed for torsional movement by a very precise measuring procedure. It was found that otolith activity as indicated by counterrolling decreased in a regular fashion as the gravitational force was reduced. In the weightless environment tilting of the subject had little effect upon this otolithic reflex; within the 0.5 G force field, the magnitude of the response fell somewhat short of those values midway between the zero and 1 G values and thus, was less than might be predicted. The significance of the findings is discussed. The L-D subjects manifested a greatly reduced but similar pattern to the normals which indicated that principally otolithic, not extralabyrinthine, function was measured in the experiment.

Cardiovascular Aspects of Hypogravics. PERRY B. MILLER, BRYCE O. HARTMAN, and ROBERT L. JOHNSON, USAF School of Aviation Medicine, Brooks AFB, Texas.

Weightlessness and the supine position have one thing in common, the absence of a positive vertical g force parallel with the long axis of the body. The absence of positive vertical g force induced by bed rest is known to result in the loss of mechanisms enabling circulatory adaptations to changing g force application.

Sixty subjects have been tested with the tilt table procedure before and after two weeks of bed rest. Before the hypogravic period 11 per cent of the subjects had syncopal or pre-syncopal reactions and after the two-week hypogravic period 42 per cent had evidence of circulatory collapse. Only 13 subjects had evidence of circulatory collapse when an anti-gravity suit was worn during the tilt table testing after the two-week hypogravic period. Forty-eight of these subjects then underwent four weeks of ambulation and training and 10 additional subjects were used as controls. These individuals had a second two-week hypogravic period induced by bed rest. Different procedures were used to study the influence of maintaining adequate circulatory adaptive mechanisms.

The results of these studies have demonstrated that a two-week period of relative absence of vertical positive g force commonly results in circulatory collapse upon exposure to positive vertical g. A significant decrease in manifestations of circulatory collapse can be effected by the use of the anti-g suit during tilt

table testing and, finally, that some decrease in deterioration of normal circulatory adaptations can be effected by certain training and maintenance procedures.

Crash Injury Analysis of X-15 Inverted Impact. S. R. MOHLER, A. H. SCHWICTENBERG, and E. BLICK, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma-Lovelace Foundation, Albuquerque, New Mexico, and University of Oklahoma, Norman, Oklahoma.

On November 9, 1962, the X-15-2 rolled over after touchdown following what was flight 31 at Edwards Air Force Base. The pilot, Mr. John B. McKay, jettisoned the canopy when the rollover became imminent. When the forward fuselage of the inverted X-15 struck the ground, the pilot received near fatal impact forces in the longitudinal axis of his body, headward to footward ($-G_Z$).

By virtue of the complex accelerometer and attitude instrumentation installed in the X-15 the quantitative dynamics of the events associated with the crash have been determined. In addition, detailed pre- and post-accident medical assessments of the pilot are available, including critical roentgenograms of the spine.

Following the accident, the pilot was two centimeters shorter in height, a result of compression fractures of five thoracic vertebrae (T-3, T-4, T-5, T-6, and T-7). Also, a loss of vital capacity occurred (from 4.87 liters to 4.06 liters) due to the post-accident kyphotic change. The soft tissue injuries included the production of an inguinal hernia.

In view of the fact that data concerning the survival tolerance to impacts in the (G_Z) axis are scarce and fragmentary, this accident, with its associated instrumentation, enables us to accurately pinpoint the forces involved and correlate these with the injuries. An analysis of the tracings at the pilot's seat reveals that the ($-G_Z$) velocity at the time of impact was 13.7 feet/second, and that deceleration in this axis occurred during 10 milliseconds, giving approximately 42 gs during this period.

Since this uniquely instrumented aircraft was involved in an accident that imposed headward to footward forces on the pilot which were considerably above the fail points for vertebral compression, but were just below the fatal injury level for separation of the heart from the inferior vena cava, additional biomedical impact data are available for completing the "Tables of Human Tolerance of Impacts." Additional aspects of the accident will be discussed, including the implications for crash-safety design. Mr. McKay has returned to full flying status.

Biological and Instrumentation Designs for Living Human Cell Studies in Orbiting Satellites. P. O'B. MONTGOMERY and JAMES E. COOK, University of Texas Southwestern Medical School and Woodlawn Hospital, Dallas, Texas.

Biological studies in satellites offer the opportunity to observe single living human cells in the space environment. This paper will present the biological requirements and instrumentation techniques for the maintenance of human cell tissue cultures in orbiting satellites for 21 day experimental periods. The equipment required for observing these cell cultures during the 21 day period will be described in detail. It consists of a modified time lapse motion picture camera, a miniaturized microscope and the necessary electrical components for illumination of the microscope and operation of the camera. Specialized equipment has been designed and constructed for the automatic feeding and maintenance of the cells. The equipment and biological parameters are so arranged that they may be utilized for human cell studies at zero gravity, for radiation studies, and for the combined effects of radiation and zero gravity. A discussion of the nature and interpretation of these experiments will be given.

Chemical Analysis of Permanent and Organic Gases in a 30-Day Manned Experiment. MELVIN L. MORRIS and WILLIAM H. TOLIVER, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Texas.

Flight 90(3-30)MD-1 was a 3-man 30 day Life Support Evaluation Study. This flight was concerned with the feasibility of regenerating oxygen from expired carbon dioxide exclusively with the Boeing Sabatier Life Support System.

This paper discusses the chemical analysis of the inorganic and permanent gases, and the trace volatile organic constituents found on this flight.

The primary instrument used was the gas chromatograph. The adjunct instrumentation was infrared spectrophotometry and mass spectrometry. Consideration is given to the sampling and analytical procedures used. Organic compounds unique to space cabin and evaluator studies are reported. Indications of future gas chromatographic methodology are given.

Coronary Flow Response to Hypocapnia Induced by Hyperventilation. WILLIAM J. MCARTHUR, Department of Physiology, University of British Columbia, Canada.

Coronory flow in the dog was measured by diverting left carotid flow through a constant temperature bubble flowmeter and then into the cannulated anterior circumflex coronary. Various degrees of hypocapnia were induced by hyperventilating the anesthetized animal on a respirator. After an equilibration period at each hypocapnic level blood gas determinations were made on a Fisher Clinical Gas Partitioner.

Experiments were carried out on twelve dogs and of these six were considered to be totally successful and the other six were partially successful. All results obtained tended to confirm that a linear relationship exists betwen arterial CO_2 tension and coronary blood flow. As the pCO_2 decreased so did the coronary flow and when the pCO_2 was returned to normal levels the coronary flow did likewise, but at a reduced rate.

Observations of cardiac arrythmias and systemic blood pressure closely paralleled previously reported results but heart rate decreased with hyperventilation. A mechanism for this last apparent anomaly is proposed.

The results are significant in that they may shed light on some of the more puzzling cardiac observations noted in aircrew. It is apparent that if stress induced hyperventilation also acts to reduce coronary flow the resultant debilitation of aircrew may have the most serious consequences. There is no obvious reason why similar effects should not apply to the crews of in-flight space capsules.

Metabolism of Some Snap Radionuclides in Miniature Swine. R. O. MCCLELLAN and L. K. BUSTAD, Hanford Laboratories, General Electric Company, Richland, Washington.

The possible utilization of Sr^{90}, Ce^{144}, Pm^{147} and Pu^{238} in terrestrial and space thermoelectric power generators has stimulated interest in their metabolism to provide information for evaluation of their potential hazard. A series of studies performed in miniature swine, an omnivore similar in size and certain physiological characteristics to man, will be summarized. The gastrointestinal uptake and retention of Sr^{85} on the tenth day after ingesting Sr^{85} titanate was less than 0.5 per cent with nearly all the Sr^{85} in the skeleton. Similar uptake and retention would be expected for Sr^{90} titanate; however, if the source contained other chemical forms of the Sr^{90} such as the carbonate, the uptake and retention would be substantially higher. The gastrointestinal absorption and retention of Ce^{144} and Pm^{147} on the tenth day after ingestion as a chloride or perchlorate was less than 0.1 per cent. Slightly higher concentrations were observed in liver and skeleton than in other organs. Ten days after intravenous administration approximately 80 per cent of the Ce^{144} and Pm^{147} was retained, nearly all of it in the liver and skeleton. The gastrointestinal absorption and retention of plutonium at 30 and 700 days after ingestion of Pu^{239} nitrate was less than 0.002 per cent. The liver and skeleton contained the majority of the plutonium, in nearly equal quantities. The applicability of these data obtained in miniature swine for use in evaluating the potential hazards of ingestion of these SNAP radionuclides in cases of accidental release will be discussed.

Development of a Tritium Self-Luminous Life Raft Light Source. E. B. MCFADDEN, J. D. GARNER and R. A. MASLER, Civil Aeromedical Research Institute Federal Aviation Agency, Oklahoma City, Oklahoma, and United States Radium Corp., Morristown, New Jersey.

A self-luminous light source utilizing tritium gas, a radioactive isotope of hydrogen, and a zinc sulfide phosphor is described. Development of these sources was initiated in order to alleviate conditions such as occurred during the night ditching of the Fly-

ing Tiger, Lockheed 1049H, in the North Atlantic, September 22, 1962.

The sources are primarily designed to provide survivors emerging from the ditched aircraft, or already in the water, with a visible identification of the location and attitude of the life raft and boarding stations.

Two sizes of tritium light sources were designed and tested. Eight three-inch sources emitting 425 microlamberts each of illumination were fabricated for use on the periphery of a 25 man life raft. Two six-inch sources emitting 225 microlamberts were fabricated for use at the boarding station. The special geometry of the light sources allow illumination angles greater than 180°.

The light sources are of very rugged construction and emission of visible light is continuous and not dependent upon an external source of energy. Reduction in brightness is very slow, nearly linear with time, and may be accurately predicted.

The use of self-luminous safety devices utilizing tritium is approved by the Atomic Energy Commission presents no radiation hazard to crew or passengers.

Some Effects of Hyperventilation upon Blood Chemistry. R. L. McLaughlin, Missile and Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, California.

A Drinker-Collins respirator was used to induce hyperventilation passively on five subjects. Blood samples were collected prior to, during, and after hyperventilation to determine blood chemistry changes in pH, hematocrit hemoglobin, bleeding and clotting time, and red and white cell changes. Blood sampling was continued for several weeks after hyperventilation to investigate any latent changes to the blood chemistry.

While no firm conclusions can be made from this cursory examination, this exposure appeared to elicit changes in the bleeding and clotting time during hyperventilation and a significant drop in hemoglobin 72 hours post hyperventilation.

Continuous Rapid Plotting of Oxyhemoglobin Dissociation Curves. James R. Neville and John J. Sasner, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The estimation of oxyhemoglobin dissociation curves in blood as usually performed requires independent analysis of a series of separate points, relating for each point three separate variables (pO_2, oxygen content, and oxygen capacity) in order to ascertain the shape of the curve representing the thermodynamic equilibrium between hemoglobin and oxygen partial pressure under a given set of standard conditions (pCO_2, pH, temperature, etc.). Application of polarographic technics to this problem has indicated that continuous rapid plots of this entire curve can be obtained with a single, small sample of blood diluted with appropriate buffer.

The analysis is carried out by the continuous removal of oxygen from a sample of dilute blood while simultaneously following the oxygen partial pressure in the sample polarographically. Ideally, oxygen should be removed at a constant rate until none remains. For this purpose, yeast has been added to the diluted blood, with removal of oxygen being accomplished by aerobic respiration. The polarographic current, continuously recorded against time, initially yields a linear portion (where only dissolved oxygen is utilized and the hemoglobin remains completely saturated) followed by a sigmoid portion (where both dissolved and combined oxygen are utilized). With removal of oxygen at a constant rate, the time axis of the sigmoid portion can be equated in terms of per cent saturation. It is, therefore, possible to construct oxyhemoglobin dissociation curves by plotting per cent saturation against oxygen partial pressure as determined by the relation between current and oxygen pressure.

Human Responses to Sonic Boom. Charles W. Nixon, Aerospace Medical Laboratories, Wright-Patterson AFB, Ohio.

Aircraft in supersonic flight generate pressure waves that are perceived along the ground as sonic booms. The impact of the sonic boom phenomenon upon humans has generated a great deal of concern and conjecture regarding individual responses and perceptions, group responses, and physiological responses. Data accumulated during the past several years by specific governmental and aviation agencies have provided some insight into the manner in which individuals and communities have responded to the sonic boom. This presentation will summarize these data in terms of the nature of human responses and the manner in which they occur, factors influencing acceptance of the boom, the possibility of physiological injury and/or secondary physiological effects, psychological effects, and some reports of minor damage to property and their relation to human reactions.

Some Notes on the Use of Superoxides in Non-Regenerative Air Revitalization Systems. A. W. Petrocelli and A. Capotosto, Jr., General Dynamics/Electric Boat, Groton, Connecticut.

The wide variety of long, intermediate, and short range manned space flights makes it difficult to foresee how it will be possible for the varying engineering, logistic, and economic requirements of these missions to be maintained by any one given air revitalization system. As a result, useful research and development work is being conducted on a number of promising air revitalization processes revolving around both regenerative and non-regenerative concepts.

Non-regenerative air revitalization systems should, for many years to come, provide the most economical and reliable means for maintaining a habitable atmosphere for space missions up to one man-month in duration. Thus, to meet the requirements of such missions as shuttle trips to manned space stations, military reconnaissance, collection of scientific data, and missions requiring a single unit, self-contained breathing apparatus, and the like, the development of efficient, safe, light weight, small volume air revitalization systems is important. Most attractive in this regard is the development of multifunctional chemical compounds such as the unfamiliar oxidation state compounds of the alkali and alkaline earth metals. The research goals in this area are to develop a single chemical compound which would supply breathing oxygen, remove carbon dioxide, and deodorize the atmosphere within a sealed cabin. As idealistic as this solution appears, compounds with the necessary potential have long been known. One such class of compounds is the alkali and alkaline earth superoxides. Research work in this field, including a major program at the Electric Boat Division of General Dynamics, continues to point out the potential usefulness of these compounds.

The Integrated Anthropometric Device in Naval Aerospace Research. Joseph R. Provost and Roland A. Bosee, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

The compatibility and accommodation of aircrew personnel in modern high performance aircraft and space vehicles has been handicapped by a lack of specific and detailed morphological measurements. A device has been designed by which rapid and accurate measurements may be obtained employing inexperienced personnel in a continuing program. The design criteria and the subsequent development of the device is discussed. The results of an experimental evaluation on the reliability and accuracy of the device, when employed by naval enlisted medical personnel, are presented.

Civil Aerospace Medicine in Canada. William A. Prowse, Department of Health and Welfare, Ottawa, Canada.

This paper will review the civil aviation medicine organization and responsibilities in Canada. It will outline the civil aviation medical examiner service, the civil aviation medicine medical assessment service and the consulting service. There will be a review of the current civilian physical standards along with an analysis of the information that is currently being recorded on data computing cards. Programming Canadian civil aerospace medical research and flight safety shall be outlined.

Modulated Radio Frequency Energy Used to Stimulate Audition in Totally Deaf Humans. Henry K. Puharich and Joseph L. Lawrence, Intelectron Corporation, New York, New York.

Equipment was designed to deliver an amplitude modulated carrier signal (range 46 kc to 41 mc) to the skin of the human. The energy is capacitively coupled to the skin. The elec-

trical energy thus delivered to the skin is nonacoustic. However, when it is properly coupled to the skin acoustic waves are generated in underlying tissues. Thus humans with normal hearing can be stimulated electrically to hear sounds fairly linear to the audio input.

A group of 15 patients was studied representing the spectrum of sensori-neural hearing loss from −30 db to −95 db. Three of these patients were totally deaf, one acquired and two congenital.

Bilateral severe hearing loss patients whose acoustic PB Speech Discrimination scores were 50 per cent or less, were rehabilitated with electrical hearing stimulation to show PB Speech Discrimination scores of 90 per cent or better.

Totally deaf patients who showed no response to acoustic pure tone stimulation (Qualitone MD Audiometer), and who had acoustic stimulation PB Speech Discrimination scores of zero, revealed electrical stimulation pure tone response from 120 cps to 10,000 cps and rudimentary speech discrimination with small word lists. With respect to their speech discrimination, lists of five or ten words were taught to the patients so that they could repeat them accurately vocally. The word list order was then randomized and the patients tested for vocal repetition of the test words. In general, about four out of five test words so given were repeated accurately by the patients following electrical stimulation of hearing.

Comment will be made on the electrical and biological factors involved in hearing stimulation by means of modulated radio frequency energy.

Comparison of Physiological Changes during Long Term Immersion to Neck Level in Water at 75°, 85°, 95° F Water.

E. Reeves, J. J. Benjamin, J. W. Weaver, and H. Mann, Naval Medical Research Institute, Bethesda, Maryland.

This experiment was designed to evaluate the physiological changes which result from immersion of subjects in water up to neck level for 24 hours at water temperatures of 75°, 85° and 95° F. It had previously been determined that immersion of subjects in water below 95° F resulted in a heat loss from the body which was compensated by an increase in metabolic rate. Other changes in blood morphology and blood electrolyte had been shown to occur concomitantly with increased urinary excretion of water and electrolyte. Since the previous studies had been carried out over a relatively short period of time, the present experiments were designed to evaluate such changes over a 24 hour period, not only at 95° F water temperature but at lower water temperatures as well. It was found that the three subjects increased their metabolic rate when immersed in 85° F water and were able to maintain a "normal" deep body temperature over the 24 hour period. When immersed in 75° F water, the increased oxygen consumption due to shivering was insufficient to maintain deep body temperature. In addition, the physiological discomfort of immersion at 75° F and the "spiritual failure" of these subjects caused the experiments to be terminated within 12 hours.

A Proposed Universal Safety Symbol for Drug Hazards in Aviation.

H. J. Rickard, University of Southern California, Los Angeles, California.

Aircraft can be operated safely and efficiently only if the human variables are understood and controlled. One of these variables is the airman's use of self medication.

Although pilots are generally physically inactive in a modern cockpit, mental alertness and sound judgment are of critical importance. Accidents occur when a number of things go wrong in a short time. Errors increase rapidly as control factors decrease. Surprise is frequently great and panic extreme. Both lead to mistakes in judgment and actions. Reactions that occur automatically in healthy and physically fit airmen frequently deteriorate in the unfit, regardless of cause. An airman's physiological and psychological unfitness may be induced by prophylactic or therapeutic drugs, incompatible with flight efficiency and safety. The danger may result from self medication, mistaken identity, inadvertant absence of proper medical warning or the innocent purchase of trade name drugs with properties unknown to flight personnel. Some of these medicines are incompatible with flight safety.

It is recommended that the Aerospace Medical Association sponsor the adoption of a suitable universal safety symbol for drug hazards in aviation. This recommendation is made because it is the responsibility of aviation medical personnel to assure that no one flies as an aircrew member while under medication which might impair flying efficiency and safety.

The proposed elements of such a symbol have been formulated. These elements were taken from over 400 samples proposed by pilots of all the armed forces in this country. They were student Flight Safety Officers in the Aerospace Safety Division, University of Southern California.

The symbol would be directly applicable to all flight crews and indirectly to maintenance, control and similar support personnel.

Minimum Crew Space Habitability for Lunar Mission.

Terence A. Rogers, Pacific Biomedical Research Center, University of Hawaii, Honolulu, Hawaii.

Two experienced and highly motivated subjects performed a 4-hour-on, 4-hour-off work schedule for 7 days in a capsule providing only 61.5 cubic feet per man. The purpose was to consider the feasibility of reducing the booster requirements for the lunar mission by using a two-man crew and a small capsule. The subjects performed engineering, psychological and physiological monitoring tasks. The effects of the stresses produced by the small size of the work space and by the work schedule were studied. Performance was measured in five psychometric tasks and a complex navigational task. Physiological observations included oxygen consumption, fluid and electrolyte balance, catecholamine and ketosteroid excretion, cardiovascular and neurological status.

Results showed that the experience was completely tolerable; both subjects maintained expected levels of performance throughout the test and were in condition to continue at its conclusion. The only adverse phenomena encountered were a negative calcium balance and the difficulty of one subject in remaining awake on the 0400-0800 shift at the existing level of motivation.

A Method for Determining Drug Induced Alterations in Resistance of Rats to Hypoxia.

Robert Rosenstein, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

A method has been devised whereby a "non-terminal" end point can be used for the detection of an alteration in resistance of rats to hypoxia.

An inclined plane, similar to that used in the assay for curare, was combined with a water bath and placed in a high altitude chamber. Rats placed upon the plane could either maintain their position upon the plane or enter the water bath. The water level was adjusted so as to allow the animals to move freely between water and plane. However, the rats invariably attempted to maintain a position above the water level. The altitude in the chamber was increased at the rate of 1800 ft./min. The end point was taken as the absolute pressure reached when a given animal could no longer maintain itself upon the plane. One group of twelve animals was tested at each of the following four angles (from the horizonal plane): 45°, 50°, 55°, 60°. The obtained mean end points were: for 45°, 156.7 mm. Hg; for 50° 173.0 mm. Hg; for 55°, 182.8 mm. Hg; and for 60°, 203.2 mm. Hg. Preliminary analysis indicates that there is a linear relationship between the angle of the plane and the hypoxic threshold.

Sodium salicylate, a drug known to alter oxygen metabolism, was administered in a dose of 200 mg./kg. to rats maintained at an angle of 55°. Forty minutes after drug administration the hypoxic threshold of the rats, as compared with control animals, had decreased by 23.3 ± 10.2 mm. Hg (95 per cent confidence limits).

Learning Ability of the Squirrel Monkey after Exposure to a Near Vacuum.

Duane M. Rumbaugh, San Diego State College, San Diego, California.

Thirty squirrel monkeys *(Saimiri sciurea)* served as subjects in an experiment to determine loss in learning ability as a function of three schedules of decompression from 3.5 p.s.i. to vacuum (1

mm. Hg) and return to 14.7 p.s.i. Prior to exposing the monkeys to vacuum they were given 100 object discrimination problems, each for 11 trials. As all subjects had long histories of experimentation in problems of this kind, this problem series was given primarily to define learning proficiency prior to exposure to vacuum. On the basis of their scores on these 100 problems, the subjects were assigned to four groups. *Group 1* comprised 10 monkeys and served as a control condition for the remaining groups. *Group 2* comprised 10 animals whose decompression schedule was from 3.5 p.s.i. to vacuum within 1 sec. with recompression commencing 3 sec. later. Recompression to 14.7 p.s.i. was gradual over a 30 sec. interval. *Group 3* comprised five animals who were decompressed from 3.5 p.s.i. to vacuum within 1 sec., maintained at vacuum for a 60 sec. interval, and then recompressed to 14.7 p.s.i. within 5 sec. *Group 4* comprised five animals whose decompression schedule differed from that of *Group 3* in that they were maintained at vacuum for 90 sec.

Upon recovery the animals were given additional testing with problems of the same type given prior to exposure to vacuum. The results of this testing program will be reviewed.

Head Ventilation for Aircrew Personnel. Louis J. Santa-Maria, Donald W. Dery, and Neil Miller, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

Under certain environmental conditions, the need for the alleviation of thermal stress in the head area of aircrew personnel is indicated. The object of this report is to survey laboratory investigations in the solution of this problem and to indicate for future research efforts in helmet ventilation trends which may be based on the results of current investgations. Laboratory assessment of various ventilating systems are conducted under simulated desert (110° F, 25 per cent RH) and tropical (100° F, 60 per cent RH) conditions. Laboratory subjects wearing summer flight clothing and representative headgear are exposed to the test conditions following allocation of temperature sensors on the face, head, and neck. In addition to the various skin temperatures, the degree of perspiration retention and subjective reports constitute the bases for the evaluation of helmet ventilating systems.

Zero-Gravity—The Effect of Transient Weightlessness on Binocular Depth Perception. Edwin H. Sasaki, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

This study was conducted to determine the magnitude and significance, if any, of the effect of transient weightlessness on binocular depth perception. Six distance intervals—1, 2, 3, 4, 5, and 6 cm.—were randomly displayed in a modified Howard-Dolman apparatus. Five subjects reported whether the three inspection rods appeared equal or whether one of the rods appeared in front or in back of the other two. Three experimental gravity conditions—zero G, one G, and two G—were produced by flying a C-131B aircraft through a parabolic trajectory and a supplemental one G control condition by flying in level flight.

Results indicate that binocular depth perception was not significantly affected by the transient gravity conditions of the parabolic maneuver. However, there is an indication that the future spaceman may enjoy a slight enhancement in depth perception as a result of being exposed to long periods of weightlessness.

Radiation Monitoring in Project Mercury: Results and Implications. Herman J. Schaefer, U. S. Naval School of Aviation Medicine, Pensacola, Florida.

Under contract with the Manned Spacecraft Center of NASA, radiation monitoring with nuclear emulsion packs has been carried out on all Mercury flights. The standard pack weighing 140 grams contained eight nuclear emulsion plates measuring 1 x 3 inches in a container of epoxy resin equivalent in absorption thickness to the astronaut's space suit. On the suborbital missions, the diffuse background from electrons and gamma rays as well as the proton count in Ilford G-5 emulsions in flown plates were not significantly different from sea level controls. Heavy nuclei and large disintegration stars were entirely absent in the controls and remained, in the flown plates, markedly below the freespace frequencies to be expected. Special problems arose before missions MA.-8 (Schirra) and MA-9 (Cooper) as both were expected to encounter residual electron intensities from the Starfish test and both would make severel passes through the Capetown Anomaly where the Inner Van Allen Belt dips down to satellite altitudes. In the plates of both missions, however, the electron background was not significantly different from that in the sea level controls. The proton populations centered heavily on the energy range below 100 Mev and showed a very strong directionality effect, presumably due to uneven distribution of local absorbing matter around the pack. Photomicrographs of typical visual fields of flown plates are shown.

Counteracting Effects of Training in Geometrical Constructions on Stress Produced by Maximal Sensory Isolation in Water Immersion. Karl E. Schaefer, USN Medical Research Laboratory, New London, Connecticut.

Four series of experiments were carried out with 18 medical and undergraduate students and the author. Subjects were immersed nude in a waterpool using a fixed suspension system. The waterpool was placed in a dark anechoic chamber. Water temperature was kept constant at 34.5°C. All subjects had a good knowledge of the work done in the field of sensory deprivation. Motility was restricted. They had a two-way communication, and were able to terminate the experiment at their own desire. Perceptual tests (Mueller-Lyer, size constance, Freedman's test, etc.) were carried out prior to the experiment after dark adaptation, and repeated after the experiment. Continuous recordings of ECG, EEG, respiratory rate were made. Urine samples were obtained prior to, and after, the experiment and analyzed for catecholamines. One group of six subjects, who had a four-week training period in geometrical constructions and projective geometry, were compared with a group of five subjects who had not undergone such a training. No physiological measurements were made in the first series of experiments with eight subjects. The second and third series were repeated exposures with three subjects.

Symptoms showed a marked difference to those obtained in experiments with non-patterned continuous stimulation. Based on criteria of Vernon, no visual and auditory hallucinations were observed. Visual imagery consisted of colored spots and stars. Auditory illusions were also fragments of normal imagery, like whistles, blibs, etc. Furthermore, there was no evidence of perceptual distortion found after the experiment, using Freedman's test. Vestibular symptoms, such as rotating sensations were often observed, vertigo and nausea occurred occasionally. One experiment was terminated because of violent rotating sensations. Loss of spatial orientation was the most impressive experience. Phantom limbs were reported rather frequently.

Repeated exposures revealed no change in basic experiences, e.g., spatial disorientation and phantom limbs developed if motility was fully restricted. Maximal time spent in this experiment was extended to 8.5 and 10.5 hours.

The group of students (A) who had a training program in geometrical constructions differed from the group (B) without training in the following: Time spent in the experiment, A: 5.5 hours, B: 3.5 hours. Epinephrine excretion, A: unchanged, B: significantly elevated. Norepinephrine excretion, A: slightly higher, B: significantly increased. Respiratory rate, A: decreased, B: increased. Pulse rate, A: decreased, B: increased after initial decline. Differences in EEG and preception tests will be reported.

Complex Coordination Performance and Time of Useful Consciousness. James Scow, William F. O'Connor, Ernest B. McFadden, and George E. Pendergrass, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma.

Time of useful consciousnss (TUC) has in the past been estimated through the performance of relatively simple, unpaced tasks. The present study employed a complex coordination device to present work loads more comparable to that experienced by the pilot. In addition to quantitative measures of TUC, the time to recovery of normal functioning following

restoration of oxygen was also determined, again using the complex coordinator.

Subjects were first given a training session on the complex coordinator, which requires use of both hands and both feet, presenting stimuli at a rate of approximately 50 per minute. Following the establishment of the subjects' learning plateau, experimental runs were made at 35,000 feet to determine TUC and recovery time. All subjects had previous physiological training in altitude chambers.

Neurological Abnormalities in a Population Requiring Aviation Medical Certification. JOHN H. SEIPEL, Georgetown Clinical Research Institute, Federal Aviation Agency, Office of Aviation Medicine, Washington, D. C.

The Georgetown Clinical Research Institute of the FAA is conducting a longitudinal study in aging using volunteer civilian applicants for aviation medical certification. As part of the routine profile of examinations a comprehensive standardized neurological history and examination is performed on each of these airmen. The population is roughly divided into 50 per cent flying personnel and 50 per cent air traffic controllers.

The design of a comprehensive screening neurological examination for use on an apparently normal population will be discussed.

Airmen (410) have been examined, 147 of them two or more times.

Positive findings from the present and past histories, family histories and neurological examinations will be presented for pilots and air traffic controllers, and occupational correlations will be indicated.

It will be shown that in this supposedly superior "normal" population a high frequency of neurological abnormality exists and is well-correlated with occupation. The significance of some of the specific findings will be discussed. It is apparent that standards for neurological "normality" should be reviewed.

Collection of Biological Information during Prolonged Flight Missions with "Yes and No" Data Reduction Analysis. C. W. SEM-JACOBSEN, E. KAISER, and I. E. SEM-JACOBSEN, EEG Laboratory, Gaustad Sukehus, Oslo, Norway.

Collection of information from prolonged flight mission, lasting from days to weeks, is hampered by problems of artifacts and data reduction so that vital bits are bogged down in a large amount of insignificant random information and noise.

In the present approach, the biological and environmental data are via transducers, Vesla biological amplifiers, and other equipment fed to detector bridges. This gives positive and negative output tensions according to the input signals and the criteria set. The output is fed into an 8-channel tape puncher thus reducing the data to frames of "yes and no" answers. The frames consist of one hundred characters, punchspeed 50 characters/sec.

The brain waves are punched 25 times per second. Accumulated information regarding G, vibration and rotation are given five times per second. Temperature, radiation, ECG, pulse, respiration, as well as O_2 and CO_2 are punched every 2 seconds. Time and frame numbers are also marked.

Five times a second a four-bits mastercode gives the neurophysiological, biological and psychological status of the pilot and the environmental conditions. Thus only 20 bits/sec. must be scanned to find the valuable parts of the primary data. The mastercode is set according to experience and preset criteria. By the instant analysis and reduction of the information from a prolonged flight the vital data remain available.

The Value of Heart Rate Patterns in Medical Monitoring. DAVID G. SIMONS and ROBERT L. JOHNSON, Aviation Medicine Department, Brooks AFB, Texas.

Beat by beat cardiotachometry of electrocardiogram provides a rich source of pattern information when the write-out speed is in the neighborhood of 2.5 mm./sec. These patterns provide useful information in many situations. The selection of optimal electrode sites for measuring ECG to be used primarily for tachometry under dynamic stress conditions is readily determined from the axis of the QRS loop in the vectorcardiogram. Patterns observed include changes in base rate, presence and amplitude of sinus arrhythmia, and the presence and polarity of slow wave phenomena. These various patterns have been observed during sleep, relaxed wakefulness, hypoxia, mask breathing, anxiety, physical exercise, breath-holding, hyperventilation, G stress, and F-100 aircraft flight. Specific patterns have proven useful as indicators of the level of central nervous system arousal and for assessing response to G stress. Typical patterns are identified which characteristically occur during emotional stress, exercise stress, hypoxia and hyperventilation.

Zero Gravity, Motion Performance of Pressure Suited Subjects under Zero and Lunar Gravity Conditions. JOHN C. SIMONS, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The gross motions of pressure suited (inflated) and unsuited subjects performing lunging, egressing, and landing tasks under zero- and lunar-gravity conditions were studied. The subjects were timed and filmed as they executed the tasks and were interviewed after they finished each series of tasks. Nine hundred zero- and lunar-gravity maneuvers of a large cabin aircraft were flown to accomplish this mission.

Time curves were established for combinations of clothing (suited, unsuited), gravity (zero, lunar), and mode of egress (four body position-handhold configurations). Time and body contact curves were established for the egress motion as it was influenced by changes in exit area. Orientation problems and maneuvering techniques as influenced by area and volume restrictions are discussed.

New and unique surface-free motions were found such as a seat-launched lunge motion replacing a stand up-walk-reach-pull series of motions.

Operator Performance in Simulated Low-Altitude High-Speed Flight. STANLEY M. SOLIDAY, Human Factors Group, North American Aviation, Inc., Columbus, Ohio.

Motion of a pilot's body in atmospheric turbulence incurs problems of visual efficiency, fatigues, variable stick inputs, seat restraint and bodily comfort. This study was conducted to investigate pilot performance and physiological responses under buffeting conditions in a closed loop man-machine flight system. The tests were made in a flight simulator that consisted of a vertically moving cockpit having a total travel of 12 feet, an acceleration capability of $\pm$ 6 G, and a functional control system. Equations of motion of a jet aircraft with variable sweep wings were mechanized in an analog computer associated with the simulator. Simulated low-altitude high-speed flights of one and one-half hour's duration each were made under varying conditions of gust, terrain, and airspeed. Task performance is considered in this paper.

Aircraft pitching varied with terrain and airspeed, and increased when vertical accelerations increased in magnitude. Altitude deviations increased steadily as vertical accelerations increased. Performance of the navigational task did not vary with terrain, airspeed, or accelerations. Control stick displacement and frequency of movement varied systematically with several of the experimental conditions.

A pencil-type side-stick controller was much more efficient than a conventional center-stick controller; task performance errors and total acclerations of the simulator were markedly reduced with the side-stick.

Specific applications are to operator performance in low-altitude high-speed flight in aircraft with highly swept wings, and to mission simulation. General applications are to operator performance in vehicles being buffeted in turbulent air.

Hearing Sensations in Electric Fields. H. C. SOMMER and H. E. VON GIERKE, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Electrophonic hearing, stimulated by an audio-frequency current passed through different types of electrode systems attached to various areas of the head and body, has been previously investigated. More recently, human auditory system response to modulated electromagnetic energy has been reported. The experiments to be discussed in this paper were designed to study the hearing phenomena in electrostatic fields when the

whole head or parts of its surface are exposed to an alternating electrostatic field of audio-frequency with and without a superimposed DC field. The threshold data obtained suggests there is no other auditory stimulation excepting mechanical tissue excitation by the electrostatic forces connected with such fields. Calculated threshold data for stimulation by amplitude modulated RF fields, assuming the same electromechanical excitation of normal bone and air conduction hearing, are presented and compared to the hearing phenomena in such fields reported by others.

Coriolis Effects during Pitch and Roll Maneuvers in a Piloted Flight Simulator. JOHN D. STEWART and BRANT CLARK, NASA-Ames Research Center, Moffett Field, California, and Department of Psychology, San Jose State College, San Jose, California.

This investigation was undertaken as a result of pilot's reports of the ocurrence of confusing and unusable motion cues during flight simulation studies using the Ames Five-Degrees-of-Angular-Freedom Simulator. The nature of the test maneuvers suggested that Coriolis accelerations affecting the vestibular mechanism could be the cause of the undesirable effects. It was, therefore, the purpose of this study to investigate the nature and duration of Coriolis effects experienced during pitch and roll maneuvers using this simulator. The simulator was controlled by an analog computer signal which exposed the subjects to centrifuge angular velocities from 2 to 12 rpm and pitch and roll maneuvers at 15°/sec. through cockpit rotations of 40°. The subject's task was to report the direction and duration of apparent change in body position during and following the maneuvers. Coriolis effects were reported throughout the whole range of centrifuge velocities, their durations extending well beyond the duration of the maneuvers. The results suggest that the planning of similar studies using centrifuge simulators should include a consideration of the effects of Coriolis accelerations on the pilot.

Myoelectric Servo Control. GEORGE H. SULLIVAN, CHARLES J. MARTELL, and GERSHON WELTMAN, Spacelabs, Inc., Van Nuys, California, and University of California, Los Angeles, California.

The interaction between the human operator and a machine can be described as occurring at the man/machine interface. From the machine side, this interface is bridged by displays; from the operator's side by machine controls. However, there are environmental conditions where man, unassisted by a servo boost system, may be ineffectual in machine control.

At the 1962 Aerospace Medical Association meeting the authors reported on an investigative program to demonstrate the feasibility of myoelectric control of a servo boost system to position the operator's hand. A task simulator was constructed which accepted the myoelectric imputs from sets of four muscles, performed the presented logic on the elicited myoelectric signals, provided success-failure feedback, and drove an arm splint in uniplanar up-down movement.

This paper reports the continuation of the program describing the development of the logic control center, actuators, and a splint with five degrees of freedom. Utilizing these control logics and the servo system, an investigation of the neuro-muscular feedback control loop was conducted. Dynamic manipulative tasks were performed to determine the time and error response and the system sensitivity and linearity.

Task perturbations were programmed into the system in the form the visual or kinesthetic miscues to further investigate the feedback control loop.

Finally, substitutions were made into the man/machine control loop by substituting the muscles of the left arm to control the right arm.

Spacecraft Environmental Control System Checkout. MAX SUSSMAN and DONALD F. PRICE, MRD Division, General American Transportation Corporation, Niles, Illinois, and NASA Manned Spacecraft Center, Houston, Texas.

Placing a man into space imposes a responsibility on the equipment designer of providing an encapsulated environment that will ensure astronaut survival and enhance astronaut performance. It is imperative that every precaution be taken to insure the safety of the man in space.

The difficult task of providing the life sustaining environment is entrusted to the life support or environmental control system. Space and weight limitations prohibit the use of systems having the large factors of safety normally mandatory for such hazardous applications. Thus, it becomes imperative that these systems demonstrate high reliability, requiring that they be tested and retested under every conceivable situation which may possibly be encountered in a space venture. To obtain meaningful results, tests of equipment should be conducted with human beings or man simulators producing conditions representative of both normal and stressed metabolic activities.

This paper describes a method by which an Environmental Control System (ECS) can be checked out prior to manned testing. For illustrative purposes, the Apollo ECS requirements will be stated. The operation of an ECS evaluator will then be described showing such a machine can perform checks on an ECS to insure proper operation. The testing of a cabin systems as well as individual suit loops is then discussed.

An ECS Evaluator was prepared by the MRD Division of GATC and delivered to the ECS Branch of NASA-MSC, Houston, Texas. This machine, which simulates the metabolic load of up to 5 men, will be integrated into the support facility for a space vehicle cabin simulator. This simulator will contain a 3 man ECS, which will eventually be replaced with a flight qualified Apollo command module (C/M) ECS. The simulator and evaluator will be utilized during development stages of the Apollo program and later for support testing during the operational phases of the program.

As received by MSC, the evaluator was designed to check out the cabin mode of an operating ECS. Versatility of the evaluator is shown by the fact that with minor modifications, carried out at MSC in close coordination with MRD, the evaluator now has the capability to check out the closed suit circuit system as well as cabin. Also, the machine has been adapted to perform checkout of the portable life support system (PLSS) which will sustain an individual crewman during lunar surface operation.

The experimental test setup at NASA-MSC is shown, described, and discussed. Pertinent data extracted from the tests and relationship to ECS preformance is shown.

Age Differences in Sequential Decisions and Cardiovascular Status among Pilots. JACEK SZAFTAN, Department of Experimental Psychology, The Lovelace Foundation, Albuquerque, New Mexico.

A small team of investigators has been authorized to join in the efforts to sketch what might be called, perhaps rather too ambitiously, an "ageing profile" of pilots from psychological and clinical data. On the physiological side, cardiovascular system in particular is subjected to a detailed assessment based on ballistogram stroke volume, plethysmograph and pulse wave velocity, recorded before and after exericse. Psychological appraisal includes intellectual status and personality as well as the conventional indices of sensory perception, but the main emphasis is on evaluation of the timing characteristics of sequential performance. Latencies of responses in multi-choice tasks of known information content are recorded with millisecond precision, together with error rates, and their altered characteristics are further observed under various conditions of information overload. The comparison of average rates of gain of information, with and without overload, may be said to yield an estimate of spare channel capacity. The rationale of this approach lies in assuming that any realistic estimate of the total mental load on the pilot cannot be based solely upon observation of what he is doing at any particular moment during the execution of his skill, but must also take into account all other possible decisions which he might have to make at very short notice. Preliminary results, culled from some one hundred commercial, military and experimental test pilots, ranging in age from the twenties to the sixties, suggest that age differences in the rate of gain of information are less impressive than might be expected from other data in the field of gerontology. Pilots over 40 years of age are relatively more susceptible than the younger to the effects of in-

formation overload, particularly if this involves short-term recall when some other activity intervenes during the period of retention. However, the various degrees of experimentally induced "dysphasic" impairment and "flicker vertigo" do not appear to be related to chronological age. A trend in the combined cardiovascular and psychological data can also be discerned: ranking the efficiency of cardiac output and the magnitude of reduction in the speed of decision under conditions of information overload, a negative correlation is obtained and found to be statistically reliable. Although the slowing with age, observed in the face of additional information challenge, is equivalent to reducing the rate of transmission of information, it does not unequivocally suggest a reduced capacity for discrimination and choice. Until more plausible theoretical conceptions are brought to bear on the problem at issue, the factor limiting decision and short term storage processes among the older adults appears to be in the nature of an increased "noise-level" in the central nervous system. Assuming that the agreement between the findings from psychological and cardiovascular tests is not misleading, it is possible to speculate further that a reduced rate of cerebral blood flow may contribute to the hypothetical random activity in brain cells.

Inter-Sensory Judgments of Signal Duration. TRIEVE A. TANNER, JR, R. MARK PATTON, and RICHARD C. ATKINSON, NASA-Ames Research Center, Moffett Field, California, and Department of Psychology, Stanford University, Palo Alto, California.

In previous investigations concerned with the judgment of signal duration, the stimuli whose durations were to be compared typically have been presented via a single sense modality, usually auditorily. Essentially no information has been available on the direct comparison of the durations of signals of different kinds of stimulus energy, e.g., light and sound. The present study is the first of a series planned in order to obtain such information.

Sixteen male college students each performed for 24 experimental sessions, each session consisted of a series of 512 trials. On each trial the subject judged which of two successively presented signals was longer. Throughout the experiment either of the two signals could be a light or a tone, so that on every trial the subject had to compare the durations of either two lights, two tones or a light and a tone.

The results give evidence of the following: (a) comparisons of signal duration were most accurate when both signals were of the same stimulus energy; (b) an interaction was present between the kind of stimulus energies being compared and the base signal duration. Attention is drawn to the implications of these results concerning CNS mechanisms involved in information processing. Thus, it is suggested that any theory relating the judgment of time to signal duration must take into account the sense modality stimulated by the signal.

The Influence of Body Support and Restraint on Subjective Response to Vibration. WILLIAM E. TEMPLE, NEVILLE P. CLARKE, JAMES W. BRINKLEY, and MORRIS J. MANDEL, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

A previous study of tolerance to short term sinusoidal vibration directed through the X, Y, and Z axes at frequencies of 1-20 cps indicated that the symptoms limiting exposure were in part related to loose coupling of the head resulting in impact against the rigid headrest during low frequency vibration, fatigue from holding the head away from the headrest when head buffeting became severe and non-optimal fit of a single contoured couch for several subjects. To further study the effects of coupling the subject to the vibration source, an adjustable body support system was employed in tests where the magnitude of vibration in the X, Y, and Z axes subjectively tolerable for brief periods was measured at frequencies between 5 and 20 cps. In addition to providing uniform close coupling of the torso to the vibration source, this system employed rigid coupling of the helmet to the headrest in X and Y axes; the helmeted head was allowed to move freely in the Z axis. The maximum accelerations tolerable in X and Y axis vibration were higher with the new system at frequencies under 10 cps; they were lower at frequencies above 10 cps. Both the improvement at low frequencies and decrement at higher frequencies were related to head restraint. The quality of symptoms arising in the thoracoabdominal area was similar to that with the previous system. Acceptable levels of vibration in the Z axis were, as expected, similar in the two systems. In general, fatigue was less of a limiting factor in the new system. This study shows the advantage of head restraint during low frequency vibration and indicates the need for further optimization of helmet attenuation against high frequency vibration.

Effects of Impact Acceleration on Guinea Pigs Protected by a Fluid-Filled Bladder Device. FREDERICK C. THIEDE, CHARLES F. LOMBARD, and S. DAVIS BRONSON, Northrop Space Laboratories, Hawthorne, California.

A study on the effects of impact acceleration on guinea pigs was conducted in which two methods of water immersion protection were investigated; total water immersion and enclosure in a fluid-filled bladder device. The latter is based on the principle of a water-filled, limit-stretch bladder interposed between the animal and a rigid, form-fitting outer container.

Anesthetized guinea pigs were subjected to impact accelerations up to 100 G on a drop tower while enclosed in the fluid-filled device. They were oriented headward and footward to G and inclined 12.5° toward G in a transverse orientation. A second group of animals was dropped while totally immersed in water and a third group was impacted while enclosed in the form-fitting container without the protective fluid-filled bladder.

A miniaturized pressure transducer fitted into the end of a No. 6.5 Fr. catheter was inserted into the trachea of several of the animals to record pressure changes in the lungs at impact. The extent of gross and microscopic pathology was ascertained in all exposed animals. Several unexposed controls were also sacrificed and examined for any pathology unrelated to impact effects.

Results of the study are discussed in terms of the feasibility of fluid protection for application to aerospace use.

Human Response to the Thermal Stress of Earth Re-Entry at Hyperbolc Velocities. R. S. THOMAS, R. B. JAGOW, and R. G. EURICH, Lockheed Missilies and Space Company, Sunnyvale, California.

A thermal model is developed for a six-man vehicle entering the earth's atmosphere at some 65,000 ft./sec. with an L/D of about 0.6. Entry angles of about 5° are assumed. Cabin wall temperatures (without insulation) of 200°F to 600°F result from the specific ablative heat shield weight assumptions. The main purpose of the analysis is to relate insulation weight plus cooling system weight to deep body temperature rise for this range of cabin wall temperature profiles. The IBM 7090 computer program results show deep body, front and back skin, suit, couch, equipment and wall temperatures and evaporative heat losses for various assumptions about thermal environment, protective system, and physiological response. Core-to-skin conductance and thermal regulatory sweating are treated as functions of deep body (hypothalamic) and skin temperatures as per T. H. Benzinger. The effects upon deep body and skin temperature profiles of varying assumptions about conductance, metabolism, capacitance, ventilation rate, suit radiatice properties and atmospheric composition and pressure are noted.

It is concluded that, within a wide range of reasonable assumptions about physiological response, the protective scheme recommended will result in a deep body temperature rise of less than one degree Fahrenheit for the most severe re-entry investigated. A number of remaining unsolved problems are discussed.

Interaction of Training-Entry Age with Intellectual and Personality Characteristics of Air Traffic Control Specialists. DAVID K. TRITES, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

Investigation of the interactions of training-entry ages of over 900 Air Traffic Control Specialist (ATCS) trainees in the Federal Aviation Agency (FAA) with pre-training measures of intellectual aptitudes and personality characteristics was accomplished by correlation and covariance analysis techniques. It

was found that with increasing age the largest aptitude decrements occurred in measures of non-verbal abstract reasoning and immediate memory. In contrast, aptitude measures tended to be higher for older trainees in the verbal, numerical, and some perceptual areas. Contrary to expectation, highly speeded aptitude measures reflected less decrement with age than non-speeded measures. Comparisons of aptitude measures of ATCS trainees classified as Fail in training, Pass training but later separated from the FAA, and Pass training and retained by the FAA indicated that usually the Fail group had the smallest aptitude scores, the Pass-Separated group the next smallest, and the Pass group the largest when the aptitude measures were corrected for their relationships with age. In the personality area, the measures tended to be higher for older trainees; i.e., older trainees reported themselves as being more intellectually efficient, responsible, tolerant, etc. The Fails tended to be less intellectually efficient, responsible tolerant, etc., than the other two groups; but only minor differences were found between the Pass-Retained and Pass-Separated groups. From all of the results, it can be hypothesized that, within the limitations of the variables examined, the older trainees tended to Fail or Pass and be separated more as a result of their inability to handle new, complex, non-verbal material than as a result of any overall deficiency in intellectual functioning.

Nutritional Acceptability of a Freeze-Dehydrated Diet. JOHN E. VANDERVEEN, KEITH J. SMITH, ELWOOD W. SPECKMANN, and DORATHEA P. WILTSIE, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Selected young men were chosen for a balance study to compare the nutritional acceptability of a diet containing freeze-dehydrated foods with an identical diet prepared from fresh foods. The subjects were required to maintain a carefully controlled activity schedule which provided periods of work, free time, and adequate rest. Physiological measurements were accomplished daily to ascertain the subjects' state of health and performance. All meals were precisely controlled and regularly sampled for chemical analysis. After a diet adjustment period, a complete balance study was performed on the subjects in hour-day cycles for the duration of the test. Nutrient intakes were calculated from chemical analysis of the test diet and with analysis of excretion products. From these data, a nutrient balance was established. Data will be presented on the amounts of digestible and metabolizable protein and energy found in each diet. Food acceptability was recorded by each subject on a hedonic scale after the completion of each meal.

Field Evaluation of Full Pressure Suits in Arctic Environments. JAMES H. VEGHTE, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Thermal responses of subjects wearing the full pressure suit were monitored for several days under arctic field conditions. The test program was conducted in three phases. Six subjects participated in each phase. In two phases the subjects wore two types of pressure garments with and without ancillary survival equipment. The third phase consisted of laboratory experiments to determine heat loss from clothed subjects with an infrared radiometer, and to determine the moisture accumulation within the clothing during exercise. In outdoor temperatures of −16°F, five of the six subjects with no survival equipment reached tolerance limits (skin temperature of 35°F) before 15 hours had elapsed. Termination of the experiment in each case was due to low foot temperatures. When the toe temperatures reached 35°F, flight boots were replaced with mukluks but tolerance was prolonged for only a few hours. The heat loss for the subjects who reached tolerance limits varied from −0.6 to −20.6 Kcal/m^2 hr. With the additional survival clothing and equipment, no problems were encountered during another two-day test when ambient temperatures varied from 8° to 25°F. Radiometric thermographs of the pressure garments indicated the pressure gloves, zipper in the groin, upper torso, thighs and face were high heat loss areas. As much as 600 gms of sweat was retained in the closed full pressure suits during mild exercise at −10°F. With the suit partially opened, there was a significant reduction in moisture retention within the suit. These data showed the critical need for extremity protection, ventilating the pressure garments and established the procedures for the use of pressure garments in dry cold environments.

Water Reclamation Subsystems for Space Stations. H. WALLMAN, General Dynamics/Electric Boat, Groton, Connecticut.

Two multi-filter subsystems designed to recycle dehumidification water and wash water in a space station were built and tested; they utilize activated carbon, ion-exchange resin, and bacterial or particulate filters. The dehumidification water subsystem produced potable water from air-conditioning condensate obtained from a space simulator. The wash water subsystem treated used wash water and produced water suitable for reuse as wash water. Chemical, bacterial, and organoleptic results are given.

The actual weights of the multi-filter subsystems for a 1 year mission are:

Dehumidification Water Subsystem — 9.3 lb.
Wash Water Subsystem —100.1 lb.

These weights are not minimum and could be reduced by further design and development. The frequency of canister replacement, and hence subsystem weights, are highly dependent on the composition of the waste waters. Canister life can best be determined by extended test operation in a manned space simulator.

Based on the amount of water remaining in the subsystems, the following water recovery efficiencies were calculated:

Dehumidification Water Subsystem — 99.5 per cent
Wash Water Subsystem — 99.0 per cent

Emergency Escape Systems for Army Helicopters. M. WEINSTOCK, Propellant Actuated Devices Division, Frankford Arsenal, Philadelphia, Pennsylvania.

Operational experience with Army helicopters reveals many instances where inflight hazards to crew personnel may be effectively resolved, with a resultant increase in flight safety, through the use of an emergency escape system. The planned use of helicopters as weapons platforms in direct support of military operations, and the hazards resulting from exposure under these circumstances to enemy counterfire, further supports the adoption of such systems to provide for crew safety and survival.

The presence and location of the rotor blades above the helicopter fuselage obviates the use of the conventional upward escape trajectory. Therefore, other escape trajectories were examined to determine their feasibility. One trajectory which appears promising is in the approximate shape of an "L." In operation the escapee is translated laterally from the fuselage to a distance beyond the rotor tips by a ballistic catapult, and then upward by rocket to a height sufficient for safe recovery by means of parachute. Design studies show that this arrangement is compatible with most helicopters. Dynamic tests of a full scale mocked-up system using standard escape system components in simulated ground level emergency escapes gave encouraging results.

Aeromedical problems indicated by this study include an evaluation of the physiological effects on the escapee of high lateral and vertical acceleration pulses separated by a short interval of time, and adequate means of body support. The solution of these problems will significantly improve the flight safety and survival capabilities of military helicopters.

Mechanical Impedance as a Tool in Research on Human Response to Acceleration. EDMUND B. WEIS, JR., NEVILLE P. CLARKE, JAMES W. BRINKLEY, and PAUL J. MARTIN, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

A necessary aspect of biodynamics research is the quantization of the amount and distribution of mechanical energy transmission from the environment to aerospace crewmen. The mechanical impedance is one very useful way to characterize the effect of power and energy on systems such as the human body and to evaluate protection systems. Methods were developed for measurement of force and velocity in the transient (impact) acceleration environment and for calculation of impedance for this data. The variation of human body impedance with acceleration orientation and body position was studied. The

body impedance for headward acceleration shows relatively low damping at resonances below 12 cycles per second; relatively higher damping of resonances in the same frequency range was observed in the body impedance for transverse acceleration. This corresponds to a higher incidence of subjective complaints associated with exposure to hearward acceleration as compared to complaints with the same acceleration in the transverse axes. The sensitivity of the human body to a high rate of onset, and the associated high frequency stress, is correlated with the increase of body impedance with frequency.

Effects of Gust-Induced and Maneuvering Acceleration Stress on Pilot-Vehicle Performance. THOMAS E. WEMPE, NASA-Ames Research Center, Moffett Field, California.

As an extension of previous studies by the NASA of the effects of high linear acceleration stress on pilot physiology and pilot performance, a simulator study was undertaken to assess the effects of gust-induced and maneuvering acceleration stress on pilot-vehicle performance during extended periods of low-level high-speed flight. NASA test pilots were subjected to this acceleration stress on the Ames Height Control Simulator, a device capable of realistically reproducing the vertical acceleration environment of high-speed, low-level flight.

The primary piloting task consisted of "flying" as close as possible to the terrain without ground contact by use of conventional aircraft controls while viewing aircraft instruments and a display depicting the terrain configuration ahead and below. Controlled variables were aircraft velocity. (Mach .5 and Mach 1.2), presence or absence of cab acceleration, gust intensity, duration of task (a maximum of 90 minutes), and additional secondary tasks, viz., turns, navigational arithmetic and the reading of instruments not used for flight path control.

Results will be presented showing the extent to which pilot performance in the primary task degraded due to fatigue and secondary task requirements. Comparative fixed cockpit and moving cockpit data will be presented to show the relative effects of the acceleration environment on performance of this kind of task.

Comparison of Seat Escape Systems Using the Latest Propulsion Concepts. C. C. WOODWARD and M. SCHULMAN, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pennsylvania.

Various new concepts in ejection seat propulsion systems have come into being within the last four years. Selection of the most optimum system has been complicated because of a variety of seat and aircraft configurations, design and performance parameters and physiological limiting factors.

This activity has been responsible for conducting a program to determine performance criterian which will permit sorting out the optimum system from those proposed. Problems that are being surmounted include instability due to center of gravity shift and catapult/rocket thrust, trajectory considerations, physiological tolerance, parachute and drogue entanglement and dimensional limitations inherent in various aircraft. Critical timing of the many automatic functions such as initiation of rocket thrust in syncronization with catapult pressure decay, drogue deployment, G limiter parachute shackle release and subsequent parachute deployment require proper control of the many variables. It is the objective of this activity to integrate a new propulsion device into the standard ejection seats in service to obtain increased performance with minimum modification, cost of installation and maintenance requirements.

Data acquisition has been accomplished through the use of sophisticated photographic and electronic instrumentation techniques and by the utilization of anthropomorphic dummies to simulate human displacement. Analysis of the data being accumulated will aid in focusing on a solution to this problem.

New Techniques in Pressure Suit Cooling. EDWARD C. WORTZ, DAVID K. EDWARDS, III, and THOMAS J. HARRINGTON, Garrett Corporation, Los Angeles, California.

Current pressure suit cooling techniques have been found to be inadequate in that they rely too heavily on latent cooling, involving heavy water loss, and that they require a high flow of ventilating gas through the suit. A system called ITEM (Internal Thermal Environment Management) has been devised and tested which enables adequate cooling of personnel in pressure suits with an air-flow of 2 to 6 cfm, and which requires less power for its operation than current systems. The ITEM concept involves a series of glycol-to-air heat exchangers positioned within the suit, over which the ventilating air flows. The heat removed from the suit is proportional both to the air and glycol flow rates. It is hypothesized that the dramatic heat removal observed is caused by a condensation-evaporation cycle of water vapor in the vicinity of the heat exchangers. Further research is required to establish an optimum heat exchanger design and configuration within the suit.

Metabolism and X-Ray Sensitivity of Chick Embryos Incubated in a Helium-Oxygen Atmosphere. R. A. WRIGHT, M. A. LESSER, and H. S. WEISS, Department of Physiology, Ohio State University, Columbus, Ohio.

The metabolism of embryonic tissue from fertile chicken eggs incubated for four or eight days in a mixture of 79 per cent helium and 21 per cent oxygen was compared with tissue from control eggs incubated in air. Sensitivity to x-irradiation was also compared. Twenty-four, four-day-embryos were dissected free of the extra-embryonic tissues and transferred intact into Warburg flasks containing Romanoff's solution plus glucose and gassed with 100 per cent oxygen. Respiratory measurements indicated no significant difference between the air incubated and $He\text{-}O_2$ incubated embryos. Some of the embryos were subjected to 250r x-irradiation at 85 kvp in air. The irradiated embryos (both air and $He\text{-}O_2$ incubated) showed an average 8 per cent decrease in metabolism when compared with the non-irradiated embryos.

Sixty, eight-day-embryos were homogenized prior to irradiation and metabolic studies. Oxygen consumption of the $He\text{-}O_2$ incubated chick homogenates, studied by the Warburg technique, was 36 per cent lower compared to air incubated chick homogenates. Air incubated chick homogenates x-irradiated at 1200r showed a decrease of 20 per cent in oxygen uptake, but $He\text{-}O_2$ incubated chick homogenates showed a decrease of only 10 per cent. Irradiation at the 600r level had essentially no effect on the oxidative metabolism of either type homogenate.

Changes in Lung Volumes of Emphysema Patients upon Short Exposures to Altitudes of 18,000 Feet (Chamber). R. L. YANDA and H. L. HERSCHENSOHN, Hospital of the Good Samaritan, Los Angeles, California, and Douglas Aircraft Company, Santa Monica, California.

A theory of lung volume changes that should result from exposure to hyperbaric environments in pulmonary emphysema patients was postulated. A detailed study of the prediction was performed with 12 patients at pressures of 2 atmospheres absolute. Beneficial clinical and statistically significant changes were demonstrated in 6 out of 12 patients, and persisted for a variable period (days to weeks).

Hence it was necessary to determine if the mechanism of action postulated was operative. If the effects were due to changing differentials of pressure then comparable changes at hypobaric levels should be demonstrable.

Four patients from the previous study were then exposed to an altitude of 18,000 feet, the sequence was 0 to 18,000 feet in 45 minutes with the patients breathing ambient oxygen 100 per cent. Premedication with aminophyllin and inhalations of isuprel during the barometric change minimized air trappings. After 5 minutes at 18,000 feet the patients were rapidly pressurized (18,000 feet to 0 feet in 5 minutes).

Serial residual volumes, total lung capacity and vital capacity measurements were then performed daily for a week. There was an immediate significant change in the Residual Volume in all patients. The changes exceeded three standard deviations. The duration of the change was 2 days.

Hence on the basis of this limited trial changing differentials of pressure can result in a beneficial redistribution of air in the lungs of emphysema patients. This study should not only be repeated in further emphysema patients but also extended to a study of normal individuals.

The Decision to Eject. ANCHARD F. ZELLER, Life Sciences Group, Directorate of Aerospace Safety, Norton AFB, California.

The increasing number of aircraft equipped with ejection systems makes it desirable that there be an evaluation of the wisdom with which this equipment is used. All major United States Air Force aircraft accidents for a recent calendar year were examined in which crewmen ejected as well as those in which they did not.

Conditions associated with the accident as well as the results were compared for the two groups. With some glaring exceptions, crewmen consistently chose the course of action conducive to both personal survival and minimum loss of equipment.

Effects of Topischemia, A Temporary and Localized Cerebral Ischemia. STANLEY A. R. ZIEMNOWICZ, Georgetown University Medical Center, Washington, D. C.

A new method is presented of temporary impairment of circulation inducing local hypoxia and anoxia in selected unilateral or bilateral areas of the brain cortex and the adjacent white matter tissue.

A special instrumentation has been constructed to provide a constant recorded pressure or suction directly on the brain surface or through the intact dura.

The topischemia, either subdural or transdural, induces in sequence: venostasis, arterial anemization and cortical edema. All these are reversible if the procedure is of very short duration.

The topischemia may induce only a laminar cortical lesion followed by an atrophy or ischemic loss of neurons mainly in the superficial upper layers. The glial tissue remains active and the vascular structure normal. This procedure is based on the selective vulnerability of different elements in the cerebral tissue. By proper timing it is possible to obtain a transient lesion of neurons. When the procedure is longer, the neuronal lesion can be irreversible. The topischemia of even longer duration will induce damage to the glial tissue and finally also to the vascular structures, resulting in the necrosis of the whole block of the area involved.

The application of this method of cortical ischemization in research on the dynamics of local anoxia and asphyxia, of brain edema, changes in blood-brain barrier and in focal epilepsy, as well as in clinical application in intractable pain is discussed.

The fluorescein and dye flows in the cortex, during and after operation are demonstrated in a short film. Neuropathological material showing the results of cerebral hypoxia and anoxia are discussed.

Human Factors Consideration for an Orbital Maintenance and Materials Transfer Shuttle. CARL R. ADAMS and GEORGE HANIFF.

This paper is a result of work accomplished partly as independent company research and as a culmination of work required to fulfill contractual commitments for an orbital maintenance and materials transfer shuttle.

Essentially, this paper contains a review of probable human space maintenance missions and a brief summary of certain inherent human restraints which are likely to influence effective accomplishment of such missions in space. Also included in this paper is a brief documentation of an empirical investigation conducted by the authors, during which a range of realistic tasks was performed by a subject in a full pressure suit under simulated space maintenance conditions. Throughout the investigation, an anecdotal record was maintained by the experimenters and the spontaneous observations of the subject were recorded on tape.

As a result of the investigation and experimentation, tentative conclusions were constructed concerning appropriate modification of standard tools, one-man shuttle vehicle design and space maintenance techniques. The efficacy of the conclusions is supported by the information presented in this paper by 35 mm still photographs and 16 mm motion picture documentary film.

U. S. Navy Aircraft Weapon Systems Anthropometry. WALTON L. JONES, Bureau of Medicine and Surgery, U. S. Navy Department, Washington, D. C. and EDMUND C. GIFFORD, Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, Philadelphia, Pa.

The flight surgeon is called upon to assess clinically the capabilities of potential aviators in performing as combat military aviators. Disproportion of the aviator and his cockpit will degrade this performance as much, or more than, many other physiological or pathological conditions. In addition, new aviator equipment now requires measurements not heretofore taken and modern aircraft weapon systems require very precise operator anthropometry.

After an exhaustive study of cockpit dimensions of the naval aircraft inventory validated by actual measurements using a newly-developed plastic anthropometric manikin, it was concluded candidates could be matched best with cockpit sizes through the use of aircraft and aviator categorization based on sitting height and stature, with appropriate minimums and maximums. Anthropometric measuring devices have been designed and are being field tested for use in this program. Candidates may be assigned a size category which would become part of their official designation number. Then, by knowing cockpit sizes, the Bureau of Naval Personnel could assign the individual aviators to squadrons utilizing aircraft with commensurate cockpits. This anthropometric field test is supplying data to add to the "measured naval aviator population" and new modified tables will be appended. Supplementing this field test, a Navy anthropometric team with special devices, technicians and equipment is measuring 2,000 of the naval aviator population covering 65 dimensions including center of gravity determinations.

Now the aviation clinician, the flight surgeon, must carefully screen the aviator applicants by a host of measurements in addition to the traditional height, weight and girth.

Radiation Hazard from Contaminated Aircraft. R. E. LUEHRS, U. S. Naval Aviation Safety Center, Norfolk, Virginia.

Repeated surveys for the presence of radioactive contamination of aircraft, flight personnel and maintenance personnel aboard *USS Enterprise* CVA(N)-65 from 7 Feb., 1963 through 2 Aug. 1963 showed appreciable amounts of beta and gamma radiation due to fallout from nuclear weapons detonations. No man aboard however, attained the maximum permissible exposure as a result.

Routine checking for radioactivity in the spaces and on the outer surfaces of the *USS Enterprise* CVA(N)-65, the first nuclear carrier disclosed a sudden quantum increase in the month of October 1961. It was disclosed that rain showers washed radioactive fallout onto the decks of the ship. This contamination was carried on the shoes and clothing of workmen and ship's crew inside the ship and radioactive contaminated air was sucked into the hull through the ventilation system.

Russian nuclear weapons testing had occurred just previously. The level of contamination constituted no danger to the crew and was so low as to be undetectable to standard radiation detectors.

It was reasoned that much atmospheric contamination remained and that high flying aircraft would have deposited on them, radioactive material which would be measurable and perhaps significant.

Spot checks of aircraft were conducted during the ensuing months followed by systematic monitoring for radioactivity during the period 7 Feb. through 2 Aug. 1963 when a deployment to the Mediterranean was made by the *Enterprise*.

This paper constitutes a report of empirical sampling of air masses in the Mediterranean area during part of 1963 and in no way approaches the scholarly and definitive work of Kulp and Diek (reference 1) on this subject. At the same time, validity exists for premises set forth herein. Eighteen months had elapsed between beginning of survey and the end of nuclear testing.