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Zero-Buoyancy: Simulation of Weightlessness to Evaluate the Psycho-Physiological and Anthropometric Parameters that Affect Space Station Design. CARL R. ADAMS, M.S., and GEORGE K. BULK, B.S., Research and Development, Douglas Aircraft Co., Inc., Santa Monica, California.

This report reviews current Douglas Aircraft Company's progress and future prospect in the field of weightlessness simulation for space station crewmen at the Santa Monica facility. Description of the Psycho-physiological and anthropometric parameters as they affect space station design are presented and a number of general conclusions with reference to such simulation are drawn, based upon the underwater simulation operations which have been conducted to date, i.e., techniques of locomotion, restraint, sleeping and exercise. In addition to the actual empirical experience which has been gained in such simulation, a review is presented of recently completed and current research which is directly relevant to this problem. Several areas in which research in this field should be accelerated are identified.

Specific observations made during the demonstration indicated that: (1) Locomotion techniques utilized demonstrated that two-handed translation was acceptable for guided motion, free-motion gliding was satisfactory in ease of performance, velcro tape walking was satisfactory for very slow body translations and compression walking was acceptable for normal translations. (2) Various sleeping positions were studied and found to be acceptable if some form of restraint is provided. (3) Restraint methods investigated indicated that reactive motions resulting from applied forces were either greatly reduced or virtually eliminated by the use of various restraint devices, i.e., belt-ring special shoes, hand rail, etc.

The Dynamic Performance of Aircrew Breathing Equipment. G. R. ALLEN, Ph.D., and G. F. ROWLANDS, M.S., Human Engineering Division, Farnborough, England.

The deficiencies of steady flow tests for assessing the performance, in particular the breathing effort characteristics of aircrew breathing equipment, are demonstrated from fundamental considerations backed by experimental evidence. The standard British test for dynamic response is described, and the flow characteristics of the breathing simulator employed are compared with the breathing conditions likely to apply in service. Typical results of steady and dynamic flow tests are presented. The usefulness of breathing simulators for routine and research work on aircrew breathing equipment is discussed, and a simulator being developed at R.A.E., which can be programmed to reproduce a wide range of breathing patterns, is briefly described. The problem of accurate measurement of dynamic breathing pressures and flows is considered, and techniques for dynamic calibration of recording equipment are described.

British work on the associated problem of instability in breathing equipment is outlined, and the nature and causes of the phenomenon are briefly discussed. Instability is shown to be a function not solely of an individual component, but rather of the complete system, including the regulator, the plumbing and the user. Thus, the impedance of the human respiratory system cannot be ignored, and techniques for its measurement are described and preliminary test results presented. Methods of simulating this impedance and the human breathing signal for stability assessment tests are discussed. Results are given of preliminary work aimed at defining levels of pressure oscillation acceptable to aircrew.

Certain principles to help improve system response and stability are elucidated.

Bends in Oxygen-Nitrogen Mixtures During Exercise at Decreased Pressures. T. H. ALLEN, Ph.D., K. G. IKELS, M.A., and CAPT. E. A. DEGNER, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Bends experiments were performed with 32 men who were snbjected to a set of 4 simulated flights lasting from 10 to 21 hours. First (Prior to Launch), oxygen was breathed through a mask for either 1.5 or 4 hours at a pressure of 14.5 psia. This was continued for 2.5 hours at 5.0 psia (Gemini Orbit) and thereafter for 15 minutes with 3 bouts of exercise at 3.5 psia (Transfer in Pressure Suit). They next remained "in shirtsleeves" either for 4 hours in "pure" oxygen at 5.0 psia or from 4 to 12 hours in 46 per cent oxygen at 7.0 psia (One- or Two-Gas System of Orbiting Laboratory). Finally, they exercised every 15 minutes for 2 hours while breathing oxygen at 3.5 psia (Reconnaisance in Pressure Suit). The experiments ended by returning to 14.5 psia unless sooner terminated by grade 3 bends. The onset, duration, and location of all grades of bends were noted. At several stages, venous blood was analyzed for dissolved nitrogen. Body composition was calculated from tissue volume and weight. With 1.5 hours of denitrogenation, grades 1 and 2 bends occurred frequently and grade 3 bends affected 1 out of 7 men during exercise at 3.5 psia. Although bends disappeared in the two-gas, 7 psia environment, these occurred in the one-gas, 5 psia environment. Four hours of denitrogenation prevented bends during "transfer," but these appeared during reconnaissance unless preceded by 30 minutes of denitrogenation in the "laboratory."

The Validity of a Brief Vestibular Disorientation Test in Screening Pilot Trainees. ROSALIE K. AMBLER, M.S., and FRED E. GUEDRY, JR., Ph.D., Naval School of Aviation Medicine, Pensacola, Florida.

A Brief Vestibular Disorientation Test (BVDT) has been developed that involves an assessment of subjects' reactions produced by head movements in a rotating chair. Reliability of measurement has been demonstrated by the substantial agreement among several types of observers using the BVDT technique for the same subjects and by the substantial agreement of the observers' BVDT ratings with the subjects' self-ratings of sensitivity. This study investigated the validity of the test for predicting various pilot training criteria.

Approximately 200 naval aviation trainees were administered the BVDT during the latter part of their pre-flight training. After the subjects had had the opportunity either to complete training or separate therefrom, the test results were evaluated for their relation to the following criteria: 1) Airsickness during aviation training flights with subsequent separation from training. 2) Airsickness with subsequent completion of training. 3) Disabling anxiety or tension associated with flight and subsequent separation from training. Results indicated that relationships existed between high sensitivity scores on the BVDT and membership in the airsick or anxiety criterion groups. The airsick/separation group had the highest mean BVDT sensitivity scores. Statistical evidence indicated that the BVDT ratings tapped a portion of the flight criterion variance not

reached by the present flight aptitude tests. The possibilities of a breakthrough in traditional selection procedures are discussed.

Techniques of Human Research for the Space Environment.

D. Amorelli, J. T. Celentano, M.D., and B. G. Peters, Space and Information Systems Div., North American Aviation, Inc., Downey, California.

This paper emphasizes the complexity and interdependency of the systems and subsystems of a space vehicle as a function of mission success. Attention is called to the environmental and space considerations and their effect on design requirements.

A matrix is given which illustrates the criticality and functional time of a major subsystem for a representative mission. The functional interrelationship of the subsystems is discussed, along with alternate concepts, and the role of man to monitor, maintain, repair, override, or substitute himself, for the function.

The effect of radiation, vacuum, and other space environmental conditions on the reliability of the systems at expected, or accidental levels, is discussed in regard to the duration, and/or the mission phase when the condition occurs.

The contribution, and design requirements, for man; his role in the guidance and control loop—and in other vehicle systems is discussed against the background of his performance in missions to date. This is supplemented with data from a series of NAA simulation studies that have been conducted, and others now being conducted. It is pointed out that on-board check-out and monitoring equipment are a requirement in order to utilize man's capabilities to identify, and repair or replace a subsystem that is functioning unsatisfactorily within the permissible "system-out" time.

The requirements for training and simulation are explained and a description given of current and proposed methods, and some of the current results and discoveries.

The Effect of Forward, Backward, Right Lateral and Left Lateral Acceleration on Blood Oxygen Saturation in Dogs.

N. Banchero, M.D., W. Rutishauser, M.D., A. G. Tsakiris, M.D., R. E. Sturm, M.S., and E. H. Wood, M.D., Mayo Clinic and Mayo Graduate School of Medicine, Rochester, Minnesota.

In six morphine-pentobarbitized dogs, blood oxygen saturations from femoral and pulmonary arteries were recorded continuously by cuvette oximeters during exposures to forward ($+G_x$), backward ($-G_x$), right lateral ($+G_y$), and left lateral ($-G_y$) acceleration. One-minute exposures to 2.1, 4.4, 6.7 and again 6.7G were performed in each body position with the animal supported in half-body casts while breathing air. In four animals, additional exposures to 6.7G were carried out in each body position while breathing 99.6 per cent oxygen. Airway pressure variations were recorded at the oral end of an endotracheal tube. Thoracic roentgenograms were taken at 1G and repeated approximately 50 seconds after attainment of the plateau level of acceleration. In addition, pressures were recorded from both atria, right ventricle, aorta, esophagus and the potential pleural and pericardial spaces. During exposures to 2.1G, no systemic changes in arterial oxygen saturation occurred in the four different positions. During forward acceleration to 4.4 and 6.7G, the arterial oxygen saturation showed mean decreases of 13.4 and 20.7 per cent after 55 seconds of exposure. Corresponding average decreases in oxygen saturation of mixed venous blood were 6.5 and 14 per cent. During backward acceleration, arterial oxygen saturation decreased 6.4 and 15.8 per cent at the two higher G levels and simultaneous decreases for mixed venous saturation were 7.5 and 15.2 per cent. During right lateral acceleration, average decreases in arterial oxygen saturation of 14.3 and 17.8 per cent occurred at 4.4 and 6.7G, respectively, while mean decreases of 19.2 and 22.2 per cent were observed during left lateral acceleration. At the two higher G levels, decreases in oxygen saturation of mixed venous blood were 10.6, 13.2 per cent for $+G_y$ and 13.1 and 15.9 per cent for $-G_y$, respectively. In all body positions, the administration of oxygen delayed but did not prevent the arterial desaturation. Thoracic roentgenograms showed displacement of the heart towards and increased in radio-opacity of the dependent regions with concomitant increase in radiolucency of the most superior portions of the lungs. (Supported in part by grants: NASA NsG-327, NIH H-3532 and AHA CI 10.)

*Barron (See Page 169)

The Influence of Eye Lid Movement Upon Electro-oculograph Recording of Vertical Eye Movements.

W. Barry, B.Sc., and G. Melvill Jones, M.A., M.B., D.R.B., Aviation Medical Research Unit, McGill University, Montreal, Canada.

Ford has drawn attention to an artifact, referred to as the "rider artifact," introduced in the records of vertical eye movements obtained by the method of electro-oculography. The present experiments were designed to investigate the cause of the artifact, and the extent of its interference with measurement of the vertical component of nystagmoid patterns of compensatory eye movement. Records of vertical eye movement were simultaneously obtained from d.c. electro-oculography and a movie-photographic method, in response to both intermittent saccadic changes in visual fixation and optokinetic and vestibular compensatory nystagmus. From the photographic data it was also possible to record vertical movement of the eye lids during all forms of response.

The results showed at the transient "rider" artifact associated with upward vertical saccades runs the same time course as that of eye lid movement, and is therefore probably directly attributable to this. An argument is advanced suggesting that changes in the relative position of the eye lid and eyeball are responsible for the artifact, rather than electromyographic activty of the levator palperae superioris. It is shown that during nystagmoid eye movement the artifact is much less marked, and that by using an appropriate angular velocity calibration method, the slopes of slow phase nystagmoid sweeps can be employed as a valid measure of eye angular velocity in the vertical plane.

Fish Electrocardiograms as a Tool in Deceleration Research.

Col. D. W. Bates, USAF(Res), Lt. Col. R. M. Bullock, USAF(Res), Maj. J. M. Shelton, USAF(Res), Capt. A. V. Zaborowski, USAF, 9410th Air Reserve Squadron, Vancouver Barracks, Washington, and Aeromedical Research Laboratory, Holloman AFB, New Mexico.

Rainbow tool (Salmo gairdinerii) were used as test subjects in obtaining useful electrocardiograms while free swimming in a fixed volume deceleration container. The method of probe fabrication, implantation and general circuitry is described as are the results of exposing 12 subjects to impacts of 10, 20, 30 and 40 G's on the Daisy Decelerator Facility, 6571st Aeromedical Research Laboratory, Holloman AFB.

Satisfactory electrocardiograms were obtained under all desired test conditions. Analysis and conclusions were completed based on suitability of tracings for study and pre and post heart rate of the subject.

It was concluded that the method devised for obtaining fish electrocardiograms does produce suitable traces for study of fish under impact conditions and can be applied to investigations in Fluid Immersion Protection.

A Review of Current Concepts and Practices Applicable to the Control of Heat Loss During Water Immersion.

Capt. E. L. Beckman, MC, USN, Cdr. E. Reeves, MSC, USN, and Ralph Goldman, Ph.D., Naval Medical Research Institute, Bethesda, Maryland.

The problem of providing adequate clothing for personnel who either accidentally or otherwise are immersed in cold water has continued to challenge clothing manufacturers for the past decade. The development of foamed plastics and other clothing materials offer new possibilities. Likewise new advances

*Abstract received after deadline for alphabetical listing.

in energy conversion systems offer new solutions to this critical operational problem.

The basic physical and physiological concepts which pertain to the problem of limiting thermal loss from the immersed human will be reviewed. The newer technical developments in insulative clothing and supplemental heating systems will be discussed with relation to these basic concepts.

Exposure of Man to Low Intensity Magnetic Fields.

DIETRICH E. BEISCHER, Ph.D., EARL F. MILLER, II, Ph.D., and JAMES C. KNEPTON, JR., M.S., Naval School of Aviation Medicine, Pensacola, Florida.

Recent magnetic explorations in the proximity of the moon have measured a very low intensity lunar field (1/400 of the geomagnetic field). During lunar landings man will become exposed to this low intensity field environment. Since no systematic observations on the physiological and psychological effects of such an environment are available, the present study makes an attempt to fill this gap.

The results of an exposure of a number of men to a field of 100 gamma (1 gamma equal to 10^{-5} oersted) for a period of 10 days will be described. The most remarkable observation was a gradual decrease of the flicker fusion threshold as exposure proceeded. Possible explanations for this effect and a discussion of other experiments (magnetocardiography) performed in the field-free environment will be presented.

Interaction of Linear and Angular Accelerations on Vestibular Receptors.

A. J. BENSON and M. A. BODIN, RAF Institute of Aviation Medicine, Farnborough, England.

Experiments in a human centrifuge showed that the time constant of decay of per-rotational nystagmus as well as the direction and velocity of spontaneous nystagmus were influenced by the direction and magnitude of the linear acceleration vector.

When exposed to a rotating linear acceleration vector, obtained by rotation of a subject on a horizontal stretcher about his longitudinal axis, nystagmus persisted for as long as rotation continued. In contrast to the observations made in the centrifuge the direction of nystagmus did not alter with position but continued to beat in the direction determined by the initial angular acceleration.

These findings, along with those of animal experiments, suggest that the signals from semicircular canal receptors can be influenced by linear accelerations, though it is not yet known whether this is brought about by a change in the physical behaviour of the canal-cupula-endolymph system or by signals from macular receptors interacting at a neuronal level.

Comparative Physical Performance of Naval Aviator Trainees from Various Procurement Sources.

JAMES R. BERKSHIRE, M.A., Naval School of Aviation Medicine, Pensacola, Florida.

All students entering naval aviation training are required to take a series of physical performance tests. After completion of the physical conditioning portion of pre-flight training the tests are re-administered. This is a study of the relative performances of men from different procurement sources on the 300-yd. run, on push-ups, and on the jump-reach test.

It is shown that there are highly significant differences in the apparent physical condition of men coming to naval aviation training from different procurement sources. Further, the groups that are poorest on their initial test performance continue to be poorest on the re-tests, although nearly all groups show significant improvement.

There are also significant differences by procurement source in the proportions of men who fail to reach minimum acceptable initial scores on all tests. In general, the physical conditioning curriculum was most likely to correct unsatisfactory performance on push-ups and least likely to improve jump-reach scores.

The implications of the findings for officer candidate and NROTC training are discussed.

Psychological and Psychiatric Problems in Commercial Aviation.

C. L. BLANC, M.D., E. LAFONTAINE, M.D., and R. LAPLANE, M.D., Service Medical d'Air France, Paris, France.

The data presented in this work are based on several hundreds of psychological interviews and neuro-psychiatrical examinations performed, as a result of pathological episodes or various incidents, on the agents of an important airline representing a population of 24,000 individuals (Flying staff, Ground personnel). Several notions emerge clearly from our studies.

1. The frequency of *psychosomatic manifestations* and *neurotic depressions* which show up in conflictual contexts.

2. *Ignorance, underestimation or disguise of psycho-affective disorders,* with *parallel emphasis of symptoms,* lived as if showing evidence of some organic disease. This attitude on the part of patients often leads to innumerable biological tests which all prove negative.

3. *Importance of non-occupational conflict factors,* with incidence on efficiency and adaptability. The ignorance of personal emotional conflicts relating to psychological traumas or to the neurotic structure of the personality, would seriously risk contaminating current investigations on adaptability, fatigue, etc. . . . These problems arise with special acuteness when it comes to discussing whether a neurotic condition or a depression incompatible with the ability must be imputed to the service.

4. *The therapeutical scope of present psychiatry* raises in the aeronautic sphere, difficult problems on a practical basis. The new psychotropic drugs (imipramine type anti-depressives, M.A.O. inhibitors, neuroleptics) have changed the clinical aspect and the evolution of neurotic and psychotic conditions. Objective recoveries under treatment do not constitute a sufficient condition of ability.

5—The interest of *systematical psychological interviews* as part of the medical selection in hiring is emphasized.

Impact Protection by the Airstop Restraint System.

CARL BLECHSCHMIDT, B.S., CARL CLARK, Ph.D., and FAY GORDON, B.S., Life Sciences Research, Martin Company, Baltimore, Maryland.

Martin Company experiments, under NASA contract, of a human airbag restraint system for airline passenger protection during an impact event have shown the advantage of load isolation by the allowed motion of the subject with respect to the vehicle.

This system called "airstop" provides controlled deceleration in the longitudinal direction (G_x) by a low pressure (3 to 10 inches H_2O) upper torso inflatable airbag, and in the vertical direction (G_z) by an inflated structure called "airseat," which at 1G looks and feels like any present-day aircraft seat, but under dynamic loading provides controlled load isolation by deforming downward and forward under the impact condition. Most significantly the seat can be deflated after the crash opening up the entire cabin as an escape corridor.

Manned and dummy experimental impact tests in an impact sled of airline seating configuration have been conducted. Swing impact tests of the complete system, with airseat, for example showed an attenuation of -54 G_x on the test vehicle impacting at 16 ft./sec. to -5.8 G_x on the subject's chest.

Full scale crash tests by the FAA (DC-7 aircraft crash test) and the Army (C-45 aircraft crash test) have included the "airstop" system to evaluate the effectiveness under real crash situations.

This paper will emphasize the testing program and the design problems of the use of the airbag restraint system in commercial and military aircraft.

Microcontactor Utilizing High-Density Metallic Superoxides.

T. V. BOLLES, M.S., H. WALLMAN, M.S., and D. ROSEN, B.A., General Dynamics/Electric Boat, Groton, Connecticut.

A laboratory prototype microcontactor, a unique and promising technique for utilizing potassium superoxide, and prob-

ably other superoxides or ozonides, in an atmosphere control system, was designed, fabricated, and tested at General Dynamics/Electric Boat. The microcontactor is a device for producing finely divided superoxide particles by grinding a block of high-density material, and then providing intimate contact between the finely divided superoxide particles and a dynamic air stream.

Preliminary laboratory tests were made to determine the grinding characteristics of high-density KO_2 (115 lb/ft^3), such as grinding rates, product size distribution, and power requirements as functions of grinder speed and force of the KO_2 block against the cutting tool. Semi-quantitative tests were made to investigate KO_2 reaction rates as functions of time, moisture concentration, and KO_2 particle size.

Based on the preliminary laboratory tests, a one-man capacity microcontactor was designed and fabricated. Test runs were made with the microcontactor under various inlet conditions of moisture and CO_2. The test results demonstrated that the microcontactor concept is feasible for application in an atmosphere control system. The microcontactor matched respiratory quotients (R.Q.) between 0.6 and 1.1 and obtained steady-state conditions with respect to oxygen and carbon dioxide concentrations after only a few minutes of operation. No overproduction of oxygen was encountered, as is commonly the case when using canisters of the superoxide.

This investigation was sponsored by the National Aeronautics and Space Administration under Contract No. NASw-551.

Mechanical Responses of Internal Organs of Animals Exposed to Sinusoidal Vibration.

LT. J. B. BOORSTIN, MC, USN, LCDR. J. R. HAYES, MC, USN, and CAPT. D. E. GOLDMAN, MC, USN, Naval Medical Research Institute, Bethesda, Maryland.

High speed X-ray cinematography has been used to determine organ motion in vibrated cats. Data processing with a motion analyzer and a computer permits rapid analysis of X-ray photographs. Results of experiments at several amplitudes and frequencies are compared to show wave distortions due to heart-lung-chest wall interactions and frequency response characteristics associated with the means of restraint of the animal and the way in which the vibratory motion is impressed. Gross and microscopic pathological studies provide correlations of mechanical response and tissue damage. Supported in part by NASA contract R-10.

Design Requirements for Life Support Helmets.

CAPT. ROLAND A. BOSEE, MSC, USN, Bureau of Naval Weapons and Bureau of Medicine and Surgery, Department of the Navy, Washington, D. C.

For some time the Navy has been considering a program for the development of a completely new life support helmet for aviators. The advent of new aircraft with radically increased performance characteristics, such as the F-111B, requires that items of pilot protective equipment be re-evaluated for adequacy. This is particularly true for the helmet, which has not been substantially revised for some years.

In November 1963 the Navy sponsored a symposium to define the specifications for an integrated life support helmet. The ultimate objective was the development of a coordinated system which would supply all the life support services required by an individual. The recommended specifications for a new helmet covered the areas of (1) general characteristics, including comfort and life support, (2) vision, (3) communications, (4) crash injury protection and (5) ventilation. Copies of the symposium proceedings, including the recommended specifications, were distributed to military facilities concerned with any aspect of this problem and to representatives of industry. The present paper considers each specification and discusses development efforts which have been started since the symposium and progress to date. Areas still in need of research emphasis also are discussed.

Hemodynamic Effects of Water Immersion.

J. A. BOWERS, M.D., CAPT. W. B. HOOD, JR., USAF, MC, R. H. MURRAY, M.D., CAPT. C. W. URSCHEL, USAF, MC, and CAPT. J. K. GOLDMAN, USAF, MC, Aerospace Medical Research Laboratories and Indiana University Cardiopulmonary Laboratory, AMRL, Wright-Patterson AFB, Ohio.

Five Air Force volunteers were studied during two separate eight-hour periods of supine water immersion and supine bed rest for changes in heart rate, blood pressure, and cardiac output (indicator dilution curves), and for alterations in blood volume (Evans Blue), urine volume and osmolarity. A dry suit with a free-breathing helmet was used for immersion. Blood sampling and measurement of hemodynamic variables utilized indwelling arterial and superior vena cava catheters. In an attempt to evaluate cardiovascular deconditioning, the hemodynamic responses to 60° head up tilt, Valsalva, and venous occlusion cuffs were also studied pre- and post-immersion and bed rest. Immersion, compared with bed rest in the same subject, produced a consistent increase in urine volume (range, 173-670 per cent) with a fall in the ratio of urine to plasma osmolarity. These changes during immersion were accompanied by a decrease in plasma volume (range, —520 to —1085 cc), slight increase in plasma osmolarity (range, 7 to 12 milliosmoles/L), and minimal increases in blood hemoglobin (range, 0.1 to 2.0 gms/%). There were no consistant changes in blood pressure, cardiac output, or heart rate during water immersion or bed rest. Clear-cut evidence of cardiovascular deconditioning was not observed. Comparable changes in blood pressure, heart rate, and cardiac output occurred both pre- and post-immersion and bed rest in response to tilt, Valsalva, or venous occlusion cuffs.

The Effect of Positive Pressure Breathing on the Vibration Tolerance of the Mouse.

J. F. BRADY, B.S., B. D. NEWSOM, Ph.D., and R. C. ARMSTRONG, M.D., General Dynamics/Astronautics, San Diego, California.

A theoretical method for attenuation of vibration stress has been developed and this study was made to test the hypothesis. Mice were exposed to ten minutes of low-frequency Z-axis mechanical vibration, control mice breathing ambient air at normal pressure and the experimental mice breathing one of three levels of positive pressure air. The vibrational stress profile was sufficient to cause a high level of tissue damage and mortality in the control mice, but showed less effect on the animals breathing positive pressure air. The two highest levels of positive pressure breathing reduced mortality significantly below that of the control mice and those breathing the lowest level of positive pressure air. The increased survival correlated well with a marked reduction in observed gross and histologic damage. The report includes macro and microphotographic comparisons of control and experimental pathology and illustrations of the apparatus designed to facilitate positive pressure breathing for the animal specimens.

Effects of Twenty Years of Flying Upon the Hearing of Naval Aviators.

VERNON C. BRAGG, Ph.D., Naval School of Aviation Medicine, Pensacola, Florida.

The subjects in the Navy's "One Thousand Aviator Study" are divided into three groups, according to their experience as flight crew members. One group dropped from the flight program before completing the training, and are essentially non-experienced as aviators. A second group completed flight training and served as aviators for four or five years during World War II, but have not flown professionally since that time. The third group is made up of career aviators who made their living in aviation essentially from flight training to retirement, or for fifteen or twenty years. The ability of each group to hear pure tones and to understand speech in noise is contrasted with that of fifty present-day aviation candidates beginning careers where the "Thousand Aviators" began some twenty-five years ago. Comparison of these four populations shows the effects which Naval Aviation has upon the aviator's hearing function. A marked effect upon pure tone threshold is noted, particularly for the high frequen-

cies. Despite the fact that many of the Aviators show losses which affect the speech frequencies, most are able to understand words satisfactorily in high-intensity noise.

Human Response to Apollo Landing Impacts in Selected Body Orientations.

CAPT. W. K. BROWN, USAF, MC, CAPT. J. D. ROTHSTEIN, USAF, MC, and 2ND LT. P. FOSTER, USAF. Biodynamics Division, 6571st Aeromedical Research Laboratory, Holloman AFB, New Mexico.

Two hundred eighty-eight human impact experiments were accomplished on the Daisy Decelerator. The purpose of these tests was to study human response to anticipated G forces in those body orientations likely to occur during impact of the earth-return module of Project Apollo. A proposed Apollo restraint system was used in all human tests. A large amount of physiological and physical data of human impact experience was obtained from the two hundred eighty-eight experiments. It was observed that impact forces produced significant effects to the neurological cardiorespiratory and musculoskeletal systems. Neurological effects of impact were momentary stunning and disorientation. A consistent effect to the cardiovascular system was transitory post-impact slowing of the heart in those body orientations in which the decelerative force acts in a footward direction (inertial force acts headward). A theory was presented to explain this physiological effect. Respiratory effects of impact were momentary shortness of breath and chest pain. Effect to the musculoskeletal system was soreness and spasm of muscle groups of the neck and back. Since no effect to any bodily system was severe enough to exceed human tolerance, the test program results demonstrate that human subjects can endure predicted Apollo landing impact forces in different body orientations without incapacitation or undue pain.

The Distribution of Pulmonary Blood Flow During Positive Acceleration.

S/L A. C. BRYAN, RCAF, and F/L W. D. MACNAMARA, RCAF, RCAF Institute of Aviation Medicine, Toronto, Canada.

The distribution of pulmonary blood flow in man during increased Positive (+Gz) acceleration has been studied using I^{131} labelled albumin aggregates. Injected intravenously these particles embolize the pulmonary vascular bed in proportion to regional blood flow. Their distribution can be subsequently determined by scintillation scanning of the lungs. Studies were done at +1G supine and seated, +2G, +3G and +4G. There was a considerable redistribution of flow under increased acceleration, with progressive decrease in apical flow and increase in basal flow. The changes fit well with predictions from the theory of pulmonary blood flow distribution, suggesting that the flow distribution for any axis or magnitude acceleration can be approximated. The gas exchange consequences of these perfusion changes have been examined.

First Degree A-V Block—Anatomy and Physiology as Illustrated by a 20-Year Follow-Up.

CAPT. ALAN R. BURES, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Marked first degree A-V block was well demonstrated and studied in this individual over 20 years ago. Subsequent serial ECG's and records of health status have become available. The causes of first degree block are discussed. The innocuous nature of some cases is noted.

USAF Whole Body Gamma Spectrometry.

LT. COL. ALVIN M. BURNER, USAF, MC, CAPT. ROBERT G. THOMAS, USAF, MSC, and MAJ. RICHARD E. BENSON, USAF, VC, Radiological Health Laboratory, Wright-Patterson AFB, Ohio.

Gamma Spectrometry has become an important adjunct in support of routine and emergency assessment of radioactivity in biological and environmental specimens. It has proved to be particularly useful for direct identification of known and unknown radionuclides present in the body and to assess the level of activities present. In accord with the increasing demand for an Air Force capability to conduct direct measurements of total body radioactivity in Air Force personnel, a whole-body gamma spectrometry facility has been established in the USAF Radiological Health Laboratory at Wright-Patterson AFB, Ohio.

The design, specifications and initial operations of this facility are presented. In particular, experience concerning background activity levels which have been observed to vary by as much as 40 per cent during a 24-hour period are discussed. Such variations in background pose a serious problem for accurate calibration and measurement of in vivo radioactivity. Studies undertaken to identify the principal source of the variation in background observed and actions taken to limit the magnitude of the background variation are reported. Techniques employed for calibration of the gamma spectrometer to facilitate yield of reliable data on disintegration rates of radioelements present in the body are described. Emphasis is placed on the importance of this capability in support of the Aerospace mission, including support of the astronauts and prolonged high-altitude Air Force missions.

Some Performance Aspects of Water Conditioned Suits.

D. R. BURTON and F/O L. COLLIER, RAF, Royal Aircraft Establishment, Farnborough, England.

This paper briefly discusses some basic ideas on personal conditioning. It describes the trend away from evaporative air cooled suits which made use of thermoregulating sweating, to the present developments of sensible heat exchange using a liquid as the heat transfer medium.

With the development of a number of water conditioned garments for experimental and demonstration purposes, an experimental technique has been evolved which enables suit performance to be investigated systematically. Results of some of these tests in high temperature environments are shown. The data have been reduced by a simple theory which allows the prediction of suitable temperature and flow conditions that will produce a comfortable and virtually non-sweating state for the wearer.

This information is essential for the design of complete systems involving water conditioned suits. It is also useful to define suitable areas of future work, to extend the capability of the suit to deal with extreme environments. Possible applications of water cooled suits are discussed, particularly those requiring portable conditioning systems, which can take advantage of the inherently low bulk and pumping power requirements to provide a capability of dealing with large temperature ranges without restricting the ability of the wearer to move about.

A Method for Determination of Calcium in Serum, Parotid Fluid and Urine in the Weightless State.

MAJ. BRUCE A. BUTCHER, USAF, MSC, A2C JOSEPH F. EASTIS and DALE A. CLARK, Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

Since the MOL Program includes on-board monitoring of calcium metabolis, a method suitable for this determination under conditions of weightlessness has been investigated. Applicable criteria include, in addition to suitability for the gravity-free state, freedom from volatile reagents that would contaminate the cabin atmosphere, absence of elaborate apparatus, low power requirement, and a reproducible, reliable, and simple procedure requiring minimal formal laboratory training. The method chosen for investigation is the Kingsley-Robnett (Anal. Chem. 33:552 (1961) modification of the Baar procedure employing Nuclear Fast Red with a colorimetric measurment at 575 mu. Analyses of calcium content of urine, serum, and parotid fluid have been performed. Standard deviations of duplicate analyses are 0.02, 0.1, and 0.05 mEq/1 respectively. In a group of 40 young men, the mean serum calcium level was 5.9 mEq/1 (range 5.4-6.4 mEq/1) and the mean parotid fluid cilcium level was 2.2. mEq/1 (range 1.5-3.2 mEq/1). Reproducibility and simplicity of this method recommend it as a "first generation" method of measuring calcium under conditions of weightlessness.

*CARLSEN (See Page 169)

Response to Carbohydrate Loading as a Criterion in Commercial Pilot Selection.

G. F. CATLETT, M.D., and G. J. KIDERA, M.D., United Air Lines Medical Department, Chicago, Illinois.

Diabetes mellitus is the second most common cause of medical grounding among pilots employed by United Air Lines, yet the disease is seldom discovered in pilot selection examinations. This study was designed to evaluate the feasibility of screening latent diabetes by use of a single blood glucose determination after administration of a loading dose of carbohydrate and to compare this method with the traditional random urinalysis. The subjects used in the study consisted of 157 consecutive pilot applicants at one of our Regional Medical Offices. All subjects were currently qualified pilots by FAA or military standards and were between 20 and 33 years of age. None gave any history suggestive of metabolic disease. Following the collection of a voided urine specimen, applicants were asked to ingest a flavored solution of 75 gms. of glucose. A blood specimen and a second voided urine specimen were collected at 60 minutes and 90 minutes respectively. The blood was analysed for glucose by the method of Somogyi and Nelson, and urine specimens were tested with Clinitest tablets. All applicants who showed glycosuria, demonstrated blood glucose in excess of 160 mgs. %, or both, were asked to submit to a conventional glucose tolerance test. In analysing results not one patient showed reducing substances in the initial urine. At the same time twelve showed positive urines and/or exceeded the critical blood level following the provocative dose of glucose. Of these twelve, ten submitted to a standard glucose tolerance test and seven (or 4.5 per cent of the total study) showed abnormal or borderline curves and were rejected as mild diabetics or poor risks in terms of susceptibility to diabetes. This study suggests that the single random urinalysis is inadequate as a selection test in choosing commercial pilots and that the response to a carbohydrate challenge should be routinely employed.

Neutral Buoyancy as a Means of Simulating 0-G Effects on Human Performance.

JOHN W. CHAFFEE, ALBERT F. EMANUEL and JAMES E. MABRY, Aero-Space Division, The Boeing Company, Seattle, Washington.

By ballasting space systems operators to neutrally buoyant in water, it is possible to simulate many of the effects upon man's gross motor behavior in the zero gravity environment. To the extent that these are analogous with those to be encountered when weightless in space, the systems designer is provided with important pre-launch information descriptive of human capabilities and requirements in systems operation, maintenance and assembly.

This paper describes the experimental techniques, facility requirements, and experimental results of an exploratory program directed toward acquiring an operational description of simulated zero-gravity effects on the operation performance. Quantitative data and films will be presented.

Compression Fractures of the Spine During USAF Ejections.

MAJ. RICHARD M. CHUBB, USAF, MC, MAJ. WILLIAM R. DETRICK, USAF, and ROBERT H. SHANNON, B.S., Life Sciences Division, OTIG, Norton AFB, California.

All ejections from United States Air Force aircraft from 1 January 1960 through 31 December 1964 were reviewed in order to determine the causes for compression fractures of the spine. The variables considered included the type aircraft and ejection seat; body position at the time of ejection; age, height, and weight of the crew member; and the various configurations of parachutes, survival kits, cushions, and other personal equipment.

Preliminary investigations revealed that a higher percentage of ejectees had compression fractures during ejections over water than during ejections over land. In addition, it was learned that the Air Training Command experienced very few compression fractures. These two statistics stimulated this more detailed investigation of the variables that probably produced the noted differences.

Design and Tests of an Inflated "Air Litter" for Transport of the Injured.

CARL CLARK, Ph.D., CARL BLECHSCHMIDT, B.S., and FAY GORDON, B.S., Life Sciences Research, Martin Company, Baltimore, Maryland.

The success of our airbag restraint work has led to the preliminary development of NASA contract of an inflated system called "air litter" for the transportation and support of the injured. The preliminary system is box-like, 1x1x2.6 meters (3x3x8 ft.), a size found unnecessarily large. It consists of outer wall compartments made of rubberized fabric 0.13m (5 inches) thick, pressurized to 14,000 newtons/meter^2 above atmospheric pressure (2 psig) and containing upper and lower full length airbags and head and foot end bags made of latex and pressurized to 700-1400 N/m^2 (0.1-0.2 psig) between which the subject lies.

With the air litter strapped feet first on a swing impact rig crashing into a wall at 6.3 m/s (19 ft./sec.), the load on the rig was -88 G_X and the load on the man's chest was $+5.5$ G_Z. A 4.9 m (16 ft.) drop 30° feet down gave $+124$ G_Z on the rig and -24 G_X on the dummy's hip.

The air litter provides surface irregularity and local load isolation as well as impact and vibration isolation. A stone or a kick is not felt inside. Thus the air litter can be transported on rough surfaces or stacked in piles with only strap tie-downs rather than the special racks required when transporting present litters. Zippers provide patient access. An improved system might provide an impeller for inflation and cooling. On reaching a hospital area, the air litter unzips to provide two beds.

Further test results, including data from a Flight Safety Foundation helicopter crash, and further potential applications will be presented.

Physiological Effects of Vibration in Animals and Man.

CAPT. J. G. CLARK, USAF, MC, CAPT. W. B. HOOD, JR., USAF, MC, R. H. MURRAY, M.D., CAPT. C. W. URSCHEL, USAF, MC, and J. A. BOWERS, M.D., Aerospace Medical Research Laboratories and Indiana University Cardiopulmonary Laboratory, AMRL, Wright-Patterson AFB, Ohio.

The effects of whole body X-axis sinusoidal vibration upon circulatory and respiratory physiology have been studied in both anesthetized animals and human volunteers. Dogs were tested in the 6 to 10 cps frequency range at 0.3 to 2.1 g peak acceleration, and human subjects in the 2 to 12 cps frequency range at 0.6 and 1.2 g peak acceleration. Measurements were made of blood pressure, indicator dilution cardiac output, heart rate, oxygen consumption, respiratory rate, minute volume of ventilation, arterial blood pO_2, pCO_2, and pH, and rectal temperature. Consistent increases in cardiac output, heart rate, oxygen consumption, and minute volume occur in both dog and man with vibration, and these are sensitive to the accelerative force of vibration. The large increases observed in minute volume were effective in ventilating mainly respiratory dead space, since blood pCO_2 and pH remained unchanged. In some instances in dogs, however, relative respiratory alkalosis was observed. Small increases in rectal temperature were sometimes demonstrated in dog and man, but these do not *per se* account for the hemodynamic changes. The circulatory and respiratory changes observed resemble those of mild or moderate exercise. Since they occur in anesthetized animals as well as man, these changes are not due simply to voluntary muscular contraction or anxiety.

Glaucoma in Flying Personnel.

MAJ. WILLIAM B. CLARK, USAF, MC, CAPT. JED L. HOWARD, USAF, MC, and LT. COL. JAMES F. CULVER, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The glaucoma policy of the US Air Force is not complex, but the underlying rationale is complicated and extremely important. The success of the policy in identifying cases and maintaining trained flyers in their duties is attributable to the administrative simplicity of the program. The most important test of its success is the assessment of medical results in individual cases.

This paper presents the results of the first test of the medical success of the policy and, therefore, of the rationale itself. With

the cooperation of each patient's flight surgeon and of the Surgeon General's Office, Hq USAF, the critical data will be presented showing the effects of the policy upon personal health and flying safety. Among other important questions to be answered will be whether the establishment of a "preglaucoma" group has resulted in significant problems.

Preliminary Evaluation of Peak vs RMS Acceleration in Low Frequency Vibration Exposures.

MAJ. N. P. CLARKE, USAF, VC, P. J. MARTIN, M.S.B.M.E., J. W. BRINKLEY, B.S., CAPT. J. H. HENZEL, USAF, MC, H. C. WOODING, B.S.E.E., and H. E. VON GIERKE, Dr. Ing., Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The vibration environment produced by turbulence during low altitude high speed flight is usually expressed as average (rms) acceleration, either with respect to time or frequency. Maximum permissible vibration intensities, both for equipment and for personnel, are also expressed this way. However, pilot experience and the general theory for behavior of mechanical and biological systems reflect that the magnitude of intermittent high peaks, in addition to the average acceleration, is a factor in determining the effect of this vibration. As the first phase of an evaluation of the importance of peak acceleration on pilot response in the range of frequencies of gust induced vibrations, ten subjects separately evaluated four pairs of 15 sec vibration (G_z) profiles to determine which of the profiles within a pair was more severe. The rms acceleration and the power density spectra of each profile within a pair was the same, but the peak acceleration was different. This was done with an acceleration pattern composed of a sine wave and its third harmonic, where the third harmonic was either in or 180° out of phase with the fundamental. Two frequency patterns and two amplitude ranges were used to form the four pairs of test environments. The frequencies were 1 with 3 cps and 2 with 6 cps. The amplitude ranges were 1.25 ± 0.75 (fundamental $\pm$ third harmonic) or 2.5 ± 1.5 g (peak to peak). In 32 of 40 pairs, subjects found the higher peak acceleration within the pair more severe ($p < 0.001$). This provides quantitative data to indicate that consideration must be given to the peak acceleration as well as the rms acceleration (i.e., the phase as well as the power density spectrum) in the frequency range of concern in evaluating the effects of buffet in low altitude high speed flight.

A New Approach to Dysbarism: Successful Therapy Without Recompression.

A. T. K. COCKETT, M.D., and R. M. NAKAMURA, M.D., Harbor General Hospital, Torrance, California, and UCLA School of Medicine, Los Angeles, California.

We noted that severe plasma loss can occur in clinical and experimental dysbarism. This observation was recently tested in a patient developing shock from decompression.

The purpose of this study is to report the effects of two separate therapeutic modalities—plasma replacement (dextran) and moderate body hypothermia in treating experimental dysbarism. Recompression was withheld.

Forty-one mongrel dogs were randomly paired and placed into the over-compression chamber. Overcompression to 73.5 PSI (gauge) and decompression were accomplished at the rate of 7 PSI per minute. Depth was maintained at 73.5 PSI for 60 minutes.

Results: Twenty-three dogs in the control groups succumbed to decompression within 6 hours.

In eleven paired experiments each control animal expired. Eleven animals (treated group) were treated with IV dextran immediately after decompression. The eleven treated animals are alive and healthy over two months since decompression.

In six paired experiments the second animal was cooled to 88° F. for a minimum of 6 hours. After 6 hours of hypothermia, dextran was infused and normothermia was reestablished. Five of 6 animals survived. The sixth animal expired 5½ hours after decompression.

These experiments clearly demonstrate the importance of plasma extravasation and subsequent circulatory collapse in dysbarism. Plasma replacement initially and finally maintenance of an effective circulating blood volume appear to be the major factors in survival.

Recompression is well established and has withstood the test of time in the therapy of decompression sickness with circulatory collapse. We believe that effective plasma replacement is important and should be combined with recompression.

Application of Water Electrolysis to the Recovery of Oxygen in Long Duration Space Missions.

C. S. COE, Ph.D., AiResearch Manufacturing Company, Garrett Corporation, Los Angeles, California.

At the present time, the most feasible processes for recovery of oxygen from metabolically-produced carbon dioxide in long-range space missions involve catalytic hydrogenation by several methods to produce water and carbon or hydrocarbons. Oxygen, and hydrogen, for recycle to the catalytic unit, are recovered by subsequent electrolysis of product water together with a quantity of the water produced metabolically. An important consideration in this process is the source and purity of the feed water to the electrolysis cell. Water derived from waste products may contain impurities which affect the purity and safety of the oxygen gas produced.

Because electrolysis requires a large quantity of electricity, it is necessary to investigate electrolytic cell design in an effort to minimize power consumption.

Although a simulated gravitational field will probably be employed in long-range missions, the possibility of conditions when no gravitational field exists may impose a requirement for zero gravity operational capability. In such an environment, separation of product gases from the electrolyte becomes more difficult. Cells designed to operate under these conditions are analyzed based on research being performed at AiResearch and elsewhere.

Integration of the water electrolysis cell into the atmospheric control system presents opportunities for additional power and equivalent weight economies. For example, operation of the electrolysis cell at elevated temperatures and pressures affords possible savings in electrical energy since the gains due to decrease in polarization outweigh the slightly increased decomposition potential required at higher pressure. Based on laboratory data detailed, analysis for several types of integrated electrolysis cell-life support systems are presented in the form of curves.

Effects of Adrenalin or Insulin on the Performance of Resting and Working Subjects.

CLAYTON R. COLER, WILLIAM A. MCLAURIN and DONALD R. YOUNG, NASA Ames Research Center, Moffett Field, California.

In a study conducted to explore the psychological and physiological effects of insulin and adrenalin on working or resting subjects, and to further the development of performance tests sensitive to stressful environments, eighteen male subjects were randomly assigned to two groups of nine subjects each. The subjects in one group received 0.05 units of insulin per kg. of body weight, following eight hours of enforced work or rest. Subjects in the other group were administered 0.10 mg. of adrenalin per kg. of body weight. The same subjects participated in both the working and resting conditions for each drug. The working state consisted of treadmill walking at approximately 2.75 miles per hour. Performance tests; two handed steadiness, running short-term memory, and choice reaction time were administered to the subjects at 45-minute intervals prior to drug injection. Following injection, the tests were given at 15-minute intervals for five sessions, with two final test sessions given at one hour intervals.

Maximum performance decrements under insulin occurred 5 to 20 minutes after injection. Performance did not return to preinjection levels at the end of three hours. The steadiness test showed a greater percentage decrement under insulin than either the short-term memory or choice reaction time. Adrenalin produced an immediate, but temporary decrement in short-term memory performance. No decrement occurred in choice reaction time or steadiness following the adrenalin injection, but a slight transitory improvement did occur in the steadiness test. Insulin had a much greater effect on performance under both

work and rest than did adrenalin. Differential effects on performance between working and resting conditions under either drug were not observed.

Vestibular Studies of Figure Skaters.

WILLIAM E. COLLINS, Ph.D., Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

Professional figure skaters who, as part of their daily routine, perform a number of high velocity spins were subjected to a series of laboratory tests consisting primarily of caloric irrigations and mild angular accelerations. Electronystagmographic recordings and motion pictures were obtained. Subjective data were also recorded. Results prompted an "on ice" study of vestibular responses employing telemetry of eye movements to an ENG recorder and motion pictures. Data were obtained during and following normal high velocity spins on ice. Results obtained were quite consistent for all skaters and lead to modifications of current theory regarding vestibular adaptation. A film will be shown demonstrating the findings.

Physical Conditioning versus $+G_z$ Tolerance.

CAPT. KENNETH R. COOPER, USAF, MC, and SIDNEY D. LEVERETT, JR., Ph.D., USAF School of Aerospace Medicine, Brooks, AFB, Texas.

Previous reports in the medical literature on the relationship between physical conditioning and human tolerance to $+G_z$ acceleration (positive G) have been conflicting. Using blackout as an endpoint, some authors have reported an increased tolerance while others have observed a decrease. Two major variables in these previous studies have been (1) the type and level of physical fitness and (2) the experience of the subjects in riding a centrifuge. Both experienced and inexperienced centrifuge subjects have used multiple means of obtaining various levels of physical fitness.

In an effort to more clearly evaluate this problem, 11 subjects from the Biodynamics Branch Acceleration/Deceleration Panel at the USAF School of Aerospace Medicine were asked to participate in this program. All of the subjects were experienced at riding the SAM centrifuge. Their ages ranged from 25 to 38 years of age and all were physically qualified under the standards of an Air Force Class III physical examination. Prior to entering the conditioning program, all eleven of the subjects were extensively evaluated to determine both their blackout tolerance to $+G_z$ acceleration and their level of physical fitness. Two types of centrifuge profiles were used: (1) ROR —rapid onset to peak G, with a plateau at peak of 15 seconds; (2) GOR—gradual onset run (.07 G/sec.) to blackout. In an effort to evaluate physical fitness, the following parameters were measured: (1) exercise tolerance on an elevated treadmill, (2) maximal oxygen consumption during exhausting work, (3) Maximal and recovery heart rates, and (4) body density determinations to obtain LBM, fat, and F/L ratios. After the initial evaluations, the 11 subjects were matched as closely as possible and divided into a control group of five and an exercise group of six. The control group specifically avoided training during the 3½-month period of the program while the exercise group ran extensively. Marked increases in physical fitness were noted in all members of the exercise group, but this in no way could be correlated with an increase or a decrease in blackout tolerance to the acceleration profiles. In addition, no significant changes were noted in the control group either in fitness or tolerance to $+G_z$ acceleration.

It is concluded that this physical fitness program, which was characterized by a highly significant increase in endurance capacity, was not related to a change in blackout tolerance.

The Effect of Acceleration and Hypohydration Upon the Peripheral Blood Leukocyte Distribution in Man.

CHARLES C. CONLEY, M.D., PATRICIA A. COOK, B.S., and JOHN E. GREENLEAF, Ph.D., NASA Ames Research Center, Moffett Field, California.

Nine healthy, male, Caucasian physical education students between the ages of 21 and 23 years were subject to a uniform regimen of diet, with mild hypohydration, and programmed exercise preceding exposure to "grey-out" levels of positive G_z, "eye balls down", centrifuge acceleration by linear ramp-up at 3 G's/minute. The end point varied between 4½ and 5 G's and was reached on 3 successive runs, so that each subject was spun 3 times for almost 2 minutes each. Venous blood specimens, drawn during the preliminary period, showed close agreement among the values of the subjects' total leukocytes and lymphocytes. Immediately following the exercise (3 minutes hard running on a treadmill, 5 minutes of the Harvard step test at 60 steps/minute), there was a transient leukocytosis; in about 1 hour, a moderate relative lymphopenia occurred. Two hours later, a more significant leukocytosis was seen in the minutes immediately following the acceleration stress, even though the subjects had been trained to relax while on the centrifuge.

Eighteen hours after the end of the acceleration, normal, pre-exercise leukocyte levels were again observed. No lymphocytosis was seen in our subjects during the week following the acceleration experience.

Alkaline phosphatase activity in the neutrophils was not significantly altered following the exercise or acceleration periods, and no abnormal leukocytes or significant morphologic trends were noted. Our findings contrast with those in the last 3 Mercury astronauts, in whom relative and absolute lymphocytoses were noted during the days following re-entry.

A Measure of Susceptibility to Psychological Stress.

LT. PATRICK M. CURRAN, MSC, USNR, and LT. ROBERT J. WHERRY, JR., MSC, USN, US Naval School of Aviation Medicine, Pensacola, Florida.

Utilizing Wherry's Theory of Psychological Stress, the three major determiners of the amount of psychological stress present for an individual in a situation are experimentally investigated. The subjects are 32 naval aviation cadets in their first week of training. The experimental situation simulates an aircraft's flight over hostile country. The subjects are instructed that the aircraft may sustain damage while over the target area (time zero). This damage is simulated by the use of electric shock: mild shock equals minor damage, painful shock equals major damage. The expected damage level is displayed on each mission. A moving light informs the subject of time elapsed during the mission and also of the proximity of time zero. The probability that damage will occur at time zero is displayed as either .20 or .80. Throughout the mission the subject performs continuously a self-paced, four-color discrimination task. The speed and accuracy of his performance are automatically recorded. Each subject completed three missions under differing combinations of probability and damage. The results of this preliminary study indicate mean decrements in behavior preceding the expected occurrence of the unpleasant event. There are substantial individual differences in the magnitude of these decrements indicating the probable satisfactoriness of this procedure as a method of measuring idiosyncratic reactions to threat.

*DAMATO (See Page 170)

Performance and Physiological Effects of Six-Hour Exposure to Helicopter Noise and Vibration.

ROBERT D. DEAN, Ph.D., CARL L. MCGLOTHEN and JAMES L. MONROE, Aero-Space Division, The Boeing Co., Seattle, Washington.

The purpose of this study was to measure the performance and physiological effects of six-hour exposure to the CH-46A helicopter noise and vibration.

Magnetic tape recording of CH-46A noise and vibration was made during a 40-minute cross-country flight. This recording was used to program a noise/vibration simulator. Six currently-qualified Navy and Marine Reserve pilots were exposed to seven 40-minute noise/vibration flights in the simulator. Ten minutes intervened between each flight and a 30-minute lunch break intervened between the third and fourth flights. A total of six hours elapsed between start of the first and end of the last flight.

Performance data were obtained on two-dimensional tracking, warning light monitoring, meter reading, visual acuity and hearing. Physiological data were obtained on heart rate, respira-

tory rate, axillary temperature, urine analyses (specific gravity, albumin, and microscopic examination), blood analyses (eosinophil count, erythrocyte sedimentation rate, serum transaminases, and serum creatine) and stool examination (hematest method).

No evidence of performance or physiological deterioration was observed.

Objective Determinations of Bone Calcium Levels.

J. M. Dick, M.D., Missile and Space Systems Div., Douglas Aircraft Company, Inc., Santa Monica, California.

The paper presents an objective method for determining the calcium levels in specified bony matricies. This method gives a relatively accurate determination (±5%) of the absolute amount of calcium present in a given cross section of bone. It is further demonstrated that this method more accurately determines the relative changes of calcium that occur in the body matricies, if the subject is exposed to "stressful" environment, *i.e.*, bedrest, or possible zero gravity.

The technique is one utilizing a radiogram of the bone in conjunction with a "standard" density wedge. The radiogram is "read" with a densitometer. The densitometer output is fed into a non-linear function transformer, the setting of which is determined by the "standard" wedge. The function transformer output, a corrected measure of the bone density, is summed or integrated across the bone image on the radiogram.

Following this general principle, this paper demonstrates how this method can be refined and adapted to fit the unsolved problem of accurately monitoring bone calcium levels during extended periods of weightlessness.

Injuries Due to Explosion, Decompression and Impact of a Boeing 707.

J. Robert Dille, M.D., and A. Howard Hasbrook, Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

On the night of May 22, 1962, an explosion occurred in the right rear lavatory of a Boeing 707. Overpressure, decompression, separation of the tail section, other breaking up of the aircraft, and, after four minutes, ground impact ensued. All 45 occupants sustained fatal injuries. One of the occupants, however, sustained relatively minor injuries, except for a laceration of the inferior vena cava, and survived for 9½ hours. The crash deceleration forces of the main part of the fuselage can be estimated. The forces transmitted to this passenger, who was lying across three forward-facing tourists seats, are more difficult to determine, but are discussed.

The approximate rate of decompression can be calculated and the possible causative roles of the decompression, the probable antecedent overpressure and the impact forces for the pulmonary lesions and the ruptured ear drums, which were found at autopsy, are discussed.

A discussion of other injuries (blast, striking the airframe, free fall) and human factors (seats, seat belts, oxygen equipment) is included.

Monitoring the Bioeffluents of Man to Establish Space Vehicle Environmental Control Requirements.

R. A. Dora, B.S., Senior Project Engineer, Beckman Instruments, Inc.; 1st Lt. James R. Clary, Project Officer, Biological Sciences, USAF; Thomas B. Weber, Ph.D., Manager, Advanced Research, Space Engineering, Beckman Instruments, Inc., Fullerton, California.

The present investigation has delineated and quantitated major constituents elicited by man. This was accomplished by employing both a bioeffluent chamber and a self-contained chemical suit. Men were isolated in the closed environments for varying periods. Both gaseous materials and particulate matter were assayed. The major volatiles consisted of pyruvic acid and butanol with significant amounts of acetone, acetaldehyde, methanol, ethanol, and ammonia. Particulate matter was evoked in relatively large amounts. The principal source of butanol appeared to be skin bacteria but there does not appear to be any metabolic pathway to account for the relatively large amounts of methanol. The principal components of desquamated epithelium proved to be calcium, sodium and potassium salts.

For a meaningful evaluation of the contaminants produced by man it is necessary to divide them into 1) those continuously emitted and 2) those exuded intermittently. The intermittent fecal and urinary components can be packaged and stored conveniently and do not constitute a biotechnological problem. Voluminous amounts of potential toxicants are continuously passed in expired air and through sensible and insensible body water losses. The latter group must be critically assayed for extended perods. The present work extrapolates the empirical data for variable periods to simulate extended orbital or interplanetary missions.

Self-Reported Stress-Related Symptoms Among Air Traffic Control Specialists (ATCS) and Non-ATCS Personnel.

John D. Dougherty, M.D., David K. Trites, Ph.D., and J. Robert Dille, M.D., Office of Aviation Medicine, FAA, Oklahoma City, Oklahoma.

In a study of six symptoms (headaches, high blood pressure, indigestion, chest pain, use of tranquilizers, and peptic ulcer) reported anonymously by 569 Air Traffic Control Specialists (undifferentiated as to type, *i.e.*, Enroute, Terminal, or Station) and 330 male GS graded, non-Air Traffic Control Specialists, it was found that:

(1) Air Traffic Control Specialists (ATCS) reported a significantly higher incidence of headaches, indigestion, chest pains, and ulcers than did the non-ATCS. This was true when new symptoms (*i.e.*, those reported as occurring only after becoming an FAA employee) were considered as well as when the incidence of new plus old symptom reports (*i.e.*, new symptoms plus pre-employment symptoms which were still present) were examined. In addition, it was found that a summary variable representing the report of any one of the six symptoms as a new symptom differed significantly between ATCS and non-ATCS. For the ATCS the rate per 1,000 for the summary variable was 352 versus a rate of 197 per 1,000 for the non-ATCS.

(2) For the ATCS, reports of specific new symptoms and the new symptom summary variable tended to increase with length of service with the FAA and CAA, GS grade, and length of experience as an ATCS.

(3) For non-ATCS, neither the incidence of specific new symptoms nor the new symptom summary variable were related to age, length of service with the FAA and CAA, or GS grade level.

(4) No significant relationships between any of the symptoms and age were elicited.

*Downey (See Page 170)

Heat Exchange During Exercise in a Helium-Oxygen Atmosphere.

W. L. Epperson, M.S., Capt. D. G. Quigley, USAF, MC, Capt. W. G. Robertson, USAF, MSC, Capt. V. S. Behar, USAF, MC, and B. E. Welch, Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The high thermal conductivity of helium has led to the belief that loss of body heat would be greater in a helium-oxygen environment than in a nitrogen environment. Studies were designed to investigate the differences in human thermal balance, comparing a helium-oxygen environment to air.

For 5 weeks, 4 men lived in a space cabin simulator and each day (in rotation) 1 man exercised for 1 hour at a work load of 100 watts on a bicycle ergometer. The first, second, and fifth weeks were in ground-level air; the second and third weeks were in a 46 per cent oxygen-54 per cent helium environment at a total pressure of 380 mm Hg. Metabolic heat was determined by indirect calorimetry, evaporative heat loss by weight change, and radiation loss and heat storage by measurement of rectal, skin, and environmental temperatures. Convective heat loss was calculated by difference. The results of these studies will be of interest in evaluating the effect of using helium in spacecraft environment.

The Influence of Alveolar Nitrogen Concentration and Environmental Pressure Upon the Rate of Gas Absorption from Non-Ventilated Lung.

S/L J. ERNSTING, RAF, RAF Institute of Aviation Medicine, Farnborough, England.

In a series of naturally respiring anaesthetized dogs, the airway to the left lung was separated from that to the right lung by means of an endobronchial cannula. In each experimental situation both lungs respired the same oxygen-nitrogen mixture (nitrogen concentration ranging between 0-80 per cent) at a given environmental pressure (within the range of 280-760 mm Hg) until a steady state was achieved. The left lung was then connected to a spirometer so that it became a closed space. The subsequent changes in the composition of the gas in the left lung and its rate of absorption were recorded. It has been calculated from the results of these experiments that, with a given concentration of nitrogen in the inspired gas, the time from cessation of ventilation to complete collapse of a segment of lung is approximately independent of the environmental pressure over the range studied in these experiments. The significance of these results will be discussed in relation to the incidence of lung collapse induced by exposure to increased acceleration.

Vertebral Fracture in Jet Aircraft Accidents; A Statistical Analysis for the Period 1959 Through 1963 in the U.S. Navy.

CDR. CHANNING L. EWING, MC, USN, U. S. Naval School of Aviation Medicine, Pensacola, Florida.

Ejections from jet aircraft account for 24 per cent of all jet aircraft accidents, but cause 60 per cent of all vertebral fractures occurring in jet aircraft accidents. The vertebral fracture rate in ejections has doubled during this reporting period, while the rate in collisions with ground and water has remained essentially unchanged.

Utilizing epidemiological methods, an effort was made to determine the causative factors of vertebral fracture during ejection. It was determined that the majority of these injuries occurred in accidents involving only a few aircraft types and that almost all of these occurred during ejection through the canopy.

These data are widely applicable in the design and evaluation of aircraft, ejection seats, and restraint harness.

Air Training Command Ejection Experience, 1 January 1962 to 31 December 1964.

CAPT. ROBERT A. FARMER, USAF, MC, LT. COL. ALONZO M. DONNELL, USAF, MC, and COL. JOHN P. MCCANN, USAF, MC, Air Training Command, Randolph AFB, Texas.

This paper presents a study of the USAF Air Training Command's experience in ejections from disabled jet aircraft. The study encompasses the three-year period of 1 January 1962 to 31 December 1964. During this period, practically all undergraduate pilot training in this command was accomplished in dual-placed jet trainers equipped with ejection seats.

The experience of Air Training Command during this three-year period indicates that the young, well-trained pilot does very well in the ejection escape situation. The analysis of 46 ejections in 1962 and 1963 reveals a success rate of 84.8 per cent. All ejections initiated above 300 feet terrain clearance were successful.

The major injury rate is a relatively low 12.8 per cent of the 39 successful ejections. There were no vertebral fractures.

Instructor and student pilots of Air Training Command represent the youngest and least experienced of USAF pilots. For 1962 and 1963, 89 per cent of the ejectees were less than 30 years of age, and 76 per cent had flown less than 200 hours in the type of aircraft involved.

These factors of training and experience, along with the factors usually presented in such ejection escape experience analyses, will be presented. This will allow easy comparison of Air Training Command and USAF experience in this important area.

Pilocarpine Effects on Visual Performance of Pilots.

RICHARD FEINBERG, Ph.D., Federal Aviation Agency, Washington, D. C.

Pilocarpine and similar miotics are used in glaucoma control. The effect of such drugs on visual performance may have serious implications for the pilot or air traffic controller. From the data gathered, it is evident that pilocarpine has a profound effect on the visual system. Whether this is due to temporary accommodation effect, the curtailment of light entering the eye, or for other cause, vision is impaired by the use of such miotics. Visual acuity for distance is markedly reduced; red form fields contract (white form fields remain intact); brightness contrast, dark adaptation, and critical flicker fusion all show detrimental effects. The implications for aero-medical concern are obvious.

Observations on Rats Exposed to a Space Cabin Atmosphere for Two Weeks.

CAPT. PHILIP FELIG, USAF, MC, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

In addition to the well-documented pulmonary damage resulting from exposure to pure oxygen at one atmosphere pressure, recent studies from this laboratory have indicated that other organs including thyroid, liver and kidney may also be adversely affected. To examine the physiologic response to the hyperoxis, reduced pressure environment used in space capsules, 6 groups of 10-15 male Sprague-Dawley rats weighing 145-155 grams were exposed to 98 per cent oxygen at a partial pressure of 258 mm Hg (5 PSI). The exposure was continued for 2 weeks during which CO_2 was maintained at less than 1.0 mm Hg, temperature at 23-25° C. and humidity at 40-50 per cent. One group received propyl-thiouracil to determine if oxygen inhalation interferred with normal pituitary-thyroid response mechanisms. Rats maintained in identical cages in room air served as controls.

Studies included observation of gross behavior, motor function and breathing pattern. At the conclusion of the exposure periods blood was obtained for determination of hematocrit, protein-bound iodine, blood urea nitrogen, phosphorus, direct and indirect bilirubin, alkaline phosphatase, and serum glutamic-oxaceloacetic transaminase. Thyroid, pituitary and adrenal tissue were examined histologically.

Of the 76 rats exposed, 75 survived and showed no evidence of gross motor or breathing difficulty. Laboratory studies revealed a minimal fall in hematocrit, but the remainder of the determinations showed no significant variations from controls. Pulmonary consolidation was found in the sole fatality, possibly due to spontaneous murine pneumonia rather than oxygen. These findings will be discussed in relation to problems of defining a threshold level for tolerance to hyperoxic environments. (Supported in part by NASA Order R-87)

Effects of Meprobamate and Hypoxia on Psychomotor Performance.

TULIO R. FIGAROLA, M.D., CHARLES E. BILLINGS, M.D., and LESTER B. ROBERTS, M.D., Department of Preventive Medicine, The Ohio State University, Columbus, Ohio.

This experiment was designed to assess the effect of meprobamate or a placebo alone and combined with varying degrees of hypoxia upon the ability of normal human subjects to perform a number of psychomotor tasks simultaneously. Six male subjects were required to perform a bidimensional tracking task, to solve coded problems and to respond to infrequent changes in the intensity of an auditory signal. This combination of tasks was performed for 36 minutes on six occasions while subjects were taking either meprobamate, 400 mg. three times daily, or a matched placebo. While taking drug or placebo, subjects were exposed in an altitude chamber to either 3,000, 8,000 or 17,000 feet pressure altitude on three separate days. Performance was assessed in each subject under each of the six combinations of altitude and drug.

The results indicate that meprobamate in this dosage exerts a decremental effect on complex task performance. This effect is approximately additive to the decremental effect of hypoxia on performance. The effect of meprobamate was obvious only

during periods when subjects were relatively heavily loaded; it was not significant at times when subjects were performing only the tracking task.

Pulmonary Mechanics at Altitude in Normal Subjects and Obstructive Lung Disease Patients.

SILVIO FINKELSTEIN, M.D., FREDERICH H. SHILLITO, M.D., and JOSEPH F. TOMASHEFSKI, M.D., Department of Preventive Medicine, The Ohio State University, Columbus, Ohio.

Previous studies on normals have shown a decrease in vital capacity, an increase in maximal voluntary ventilation and in expiratory flow rates on altitude exposure; said to be due to a decrease in the density of respired gases, expansion of trapped gases, and hypoxia.

Using conventional methods pulmonary mechanics were measured on healthy young adult males on acute exposure to equivalent altitudes of ground level, 18,000 feet and 33,700 feet in a decompression chamber. To eliminate hypoxic effects the subjects breathed 100 per cent oxygen throughout the experiment.

A marked improvement in ventilatory mechanics occurs; this is shown by an increase in the maximal voluntary ventilation and expiratory flow rates.

The normal subjects gave a baseline for comparison of results obtained in patients with obstructive pulmonary diseases when studied under similar controlled conditions. These findings may prove to be of practical importance in the management of patients with obstructive pulmonary diseases.

Some Respiratory Changes Associated with Military Flight Equipment.

LT. FRANK J. FORMELLER, MSC, USN, and K. N. TINKLEPAUGH, B.S., Life Sciences Dept., U. S. Naval Missile Center, Point Mugu, California.

In-flight pilot respiratory volume measurements in a previous study seemed to indicate a potential relation between respiratory data, pilot fatigue and psychomotor performance. This paper reports preliminary laboratory studies to establish quantitative values for the work of breathing while wearing restrictive flight clothing and using ejection seat restraint systems. The cumulative product of pulmonary pressure plus volume of air moved was utilized to measure work ($W = \int P\, dV$). Electrical transducers were used to record and integrate continuously the respiratory pressure-volume changes during static breath holding tests and during extended breathing cycles. The early results demonstrate some decreased respiratory efficiency while utilizing standard flight equipment. Redesigning the restraint harnesses may enhance the breathing efficiency. It is anticipated that this study will be continued by coupling weapon systems tracking tasks with simulated ambient altitude changes.

Experience as a Factor in Experimental Impact.

LT. PETER FOSTER, USAF, Aeromedical Research Laboratory, Holloman AFB, New Mexico.

The purpose of this study was to determine whether or not experience is a factor in the tolerance of impact. Tolerance to impact depends on several variables, among those, the magnitude of the amplification factor. Past observations of impact experiments suggest a difference between the amplification factors of experienced and inexperienced test subjects. The amplification factor is calculated as follows:

$$\frac{\text{Output (Subject Peak G's)}}{\text{Input (Sled Peak G's)}} = \text{Amplification Factor}$$

The higher the amplification factor the lower the tolerance. Two hypotheses have been offered, one being that the more experience and the greater number of accumulated G's an acceleration (or decleration) subject has, the less his amplification factor at a particular input force and position. If this be the case, then tolerance levels from past observations cannot be applied to persons who have had little or no experience. In a larger sense it would indicate that individuals can learn through experience to better tolerate impact and justifies more specifically having future astronauts undergo "impact training." The other hypothesis considers the amplification factor to be independent of experience. Therefore, data collected on impact tolerance levels are just as valid for the experienced subject as it would be for a novice who has had little or no similar experience with impact. This hypothesis would justify the use of essentially the same subjects over and over again and taking this data to be valid for any group of people, experienced or not. To determine which hypothesis was valid, 51 human subjects of varying degrees of experience were exposed to impact in the same position using the same restraint system, sled and impact profile for the sled. The amplification factors at points along the frequency distribution curve were analyzed.

In conclusion, evidence of a change in the amplification factor of subjects through experience to impact forces will enable one to better predict tolerance.

The Biochemical Post-Mortem as an Emergency in Accident Investigation.

W. R. FRANKS, M.D., RCAF Institute of Aviation Medicine and University of Toronto, Canada.

Many of the physiological responses which an individual makes in an emergency can be detected by suitable biochemical investigations even at post-mortem, when a fatal outcome ensues. These changes are apt to be labile and therefore the biochemical post-mortem constitutes an emergency. From a combined analysis of such results a final probability assessment can often be reached, which may play a vital role in determining the cause and circumstances of an accident. The human factor is peculiarly characterized by dynamic responses to the ambient conditions both in character, intensity and time, which responses can often leave identifiable biochemical scars post mortem. Thus the lungs can equate circulating blood to changes in ambient atmosphere such as variations in Oxygen, Nitrogen, Carbon Monoxide tensions. Similarly, anxiety can result in catechol amines changes, shifts in blood and tissue sugar content (P.M. lactate), and free fatty acids; hyperventilation may be differentiated by alterations in tissue ammonia coupled with elaboration of ketones. Blood distribution can shift under condition of vertigo and changes in acceleration. New responses are continuously being described. The integrated analysis of such findings to determine a final probability has the dimension of computer programming. Examples will be discussed, including information to be gained from an analysis of the distribution of lactate concentrations in various organs post mortem which facilitate the differentiation of hypoxia from an adrenergic response.

Monitoring Brain Response to Stress by Evoked Responses.

CAPT. JOHN A. FREEMAN, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

A sensitive central nervous system monitoring technique that can be correlated with behavior and with changes in the surrounding environment during aerospace flight is desirable to the flight surgeon interested in the early detection of possible adverse effects of the flight on the subject, to the neurophysiologist concerned with basic cerebral mechanisms occurring during the unique conditions of space flight, and to the systems engineer interested in any redundant indirect measurement of environmental parameters which serve to enhance the total system reliability.

In this study, a special-purpose digital computer was used to obtain average EEG responses evoked by repetitive, non-distracting clicks from human subjects during sedentary activity, mildly symptomatic hyperventilation, hypoxia, and 2.5 $+G_z$ acceleration on the SAM human centrifuge and in an NF-100 aircraft.

The waveforms obtained were qualitatively distinct for each group. No appreciable alteration of the relative amplitudes or latencies of the individual response components were caused by distraction, habituation, or variations in ambient noise. No significant effects were detectable in the corresponding EEG's. This preliminary investigation suggests that average evoked responses may be useful and sensitive indicators of CNS activity during aerospace flight.

Comparative Effects of Prolonged Rotation at 10 rpm in the Coriolis Acceleration Platform on the Postural Equilibrium Functioning of Vestibular Normal and Vestibular Defective Human Subjects.

ALFRED R. FREGLY, Ph.D., and LT. ROBERT S. KENNEDY, MSC, USN, Naval School of Aviation Medicine, Pensacola, Florida.

Pre-rotation and post-rotation postural equilibrium test battery performances of vestibular normals and vestibular defective individuals are compared to illustrate quantitatively and qualitatively (film): 1) prior to rotation, circumscribed, permanent postural equilibrium dysfunctioning in vestibular defective human subjects, relative to such functioning in normal subjects, as a consequence merely of meningitis- and mastoiditis-caused defect of the vestibular end organs (semicircular canals and utricles), and 2) by virtue of prolonged rotation, temporary but overwhelming, highly generalized, CNS-generated postural equilibrium dysfunctioning in vestibular normals and vestibular defective subjects alike observed immediately upon cessation of 12 days of rotation at 10 RPM in the Pensacola Coriolis Acceleration Platform.

Respiratory Responses to Gaseous Embolism.

WG. CDR. D. I. FRYER, RAF, RAF Institute of Aviation Medicine, Farnborough, England.

Animal experiments have been performed to measure and analyse responses to the introduction of bubbles of various gases into the pulmonary vascular tree. An attempt has been made to assess the overall effect of changes in the mechanical properties of the lungs on gaseous exchange. The relevance of the experimental findings to "chokes" and pulmonary barotrauma will be discussed.

A Novel Approach to the Measurement of Man's Heat Exchange with a Complex Radiant Environment.

A. P. GAGGE, Ph.D., J. A. J. STOLWICK, and J. D. HARDY, Ph.D., John B. Pierce Foundation Laboratory, Yale University School of Medicine, New Haven, Connecticut.

Unclothed subjects in a sitting position were exposed to a variable source of thermal radiation (two 1500-watt quartz heaters). Ambient temperatures varied between 15°C.-32°C.; air movement (less than 7 cm/sec) and relative humidity (less than 30 per cent) were constant for all experiments. Total heat loss by evaporation was evaluated from a continuous record of the subjects' weight loss while resting on a sensitive platform scale. Two series of experiments were performed: (1) the change in evaporative loss with increasing heater wattage was observed, while the ambient temperature (T_a) was constant in range 30°-32°C. and (2) the subject was allowed to choose the heater wattage necessary for a sense of comfort and thermal neutrality, while the ambient temperature varied over range 15°-30°C. From these two series, it can be shown: (a) a change in evaporative loss E corresponds to the radiant heat (H_r) absorbed by the body from the lamps; (b) the slope of the radiant heat (H_r) selected for comfort and neutrality when plotted against dropping ambient temperatures (T_a) is equal to the environmental constant, h. This constant describes how heat is lost by radiation plus convection from a skin surface at average temperature T_s to a uniform environment at temperature T_a. Thus it is possible, by using the human body as a radiometer (Exp. 1) and as a null point sensor (Exp. 2) of comfort-thermal neutrality, to describe quantitatively its heat exchange in a complex radiant environment and to evaluate the operative temperature, (*i.e.* $T_a + H_r/h$).

The Study of the Explosive Effects of Simulated Micrometeoroid Penetrations into a Sealed Gas-Containing Animal Capsule.

C. F. GELL, M.D., and RAY MCKINNEY, Ling-Temco-Vought, Astronautics Division, Dallas, Texas.

This paper discusses the two phases of work done at LTV in simulated micrometeoroid penetration of a sealed gas-containing animal capsule. Initially, work at LTV in their in-house research developed a shaped charge gun capable of firing metallic or glass pellets through a vaccum medium at a velocity of 19 to 37,000 fps. Initial firings were made into various types of metallic structures including that of an aluminum honeycomb sandwich material. When this structure was penetrated, evidence of an oxidative-energy release was demonstrated, apparently caused by the vaporization of the metal at the point of penetration, the oxygen within the cells and the generated heat. This reaction was severe enough under certain conditions to injure rats by blast and burn. In a series of 75 firings, the following observations were made: (a) the mildest oxidative energy release occurred when a container with a sea level atmosphere was penetrated; (b) any concentration of pure oxygen elicited an oxidative energy release. Maximal reaction was demonstrated in a 5 psi pure oxygen atmosphere; (c) animal fur, greasy hide or electrical insulation could cause fire following an oxidative energy release; (d) the larger the hole, the greater the possibility of an oxidative reaction; (e) firing into an aluminum sandwich whose inner content was a 90 per cent water material caused an explosive ripping of the aluminum walls, due to the expansion of the steam generated by the heat of the penetrating particle.

From this data, it appeared that if a hypervelocity particle penetrated the metallic wall of a space ship, there may be an internal oxidative energy release that could disable a space pilot by intense heat, light, blast and burning.

The above findings stimulated further work sponsored by NASA considering the factors of determining the possible limitation of an oxidative energy release. Tests were performed at five atmospheric conditions. Live animals and comprehensive instrumentation were used to determine the energy release of the particle penetration of the target plates.

Completed in February 1963, the following observations in this study are as follows: (a) Oxidative reaction following meteoroid penetration could possibly result in injury to space crews; (b) the hole size produced by a penetration is hypothesized as the most significant variable governing the energy released; (c) energy released for a given sized penetration decreases in proportion to oxygen concentration decrease; (d) practical limits fix the oxygen requirement for spacecraft at a concentration above that providing protection from oxidative explosion resulting from meteoroid penetration if the crew compartment has a single metallic wall. Space suits are similarly vulnerable; (e) maximum cabin protection is obtained when a standard atmosphere is used.

The results of the second phase indicates the requirement for continued investigation in methods of meteoroid shielding for space vehicles and a more complete analysis of the incapacitating effects on the operator produced by hypervelocity penetrations of simulated space vehicles. Tests on mammals in a standard space suit in a simulated space environment to observe the effects of potential micrometeoroid hits on a suited man are indicated.

Comparative Effects of Lower Body Negative Pressure and Orthostasis on Peripheral Vascular Reflexes.

CAPT. CHARLES A. GILBERT, USAF, MC, PAUL M. STEVENS, M.D., and LT. COL. ROBERT L. JOHNSON, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Peripheral vasoconstriction manifested by increases in venomotor tone have been well documented as a response to passive tilting to the upright position. This has been suggested as one of the mechanisms responsible for orthostatic tolerance. Lower body negative pressure has been proposed as a possible countermeasure to prevent orthostatic deconditioning during prolonged space flight.

Present studies seem to show that lower body negative pressure by sequestering a large volume of blood likewise induces vasomotor reflex changes. A striking decrease in forearm blood flow as well as an increase in forearm vascular resistance is noted but an increase in venomotor tone although present is not in the range of magnitude as that induced by normal standing. Passive tilting to the vertical position when supported by a parachute harness produces vascular changes similar to lower body negative pressures. These changes are different from the ones produced by passive tilting while standing on a footboard.

Data is presented to delineate the peripheral vascular and blood volume changes due to lower body negative pressure and vertical tilting in a harness as contrasted to those secondary to orthostasis resulting from passive standing.

*GILLINGHAM (See Page 170)

Response of Tissue Culture Cells to Low-Magnetic Fields.

A. E. GREENE, Sc.D., and M. H. HALPERN, Ph.D., South Jersey Medical Research Foundation, Camden, New Jersey, and The Franklin Institute, Philadelphia, Pennsylvania.

Literature reports on magnetic field effects on tissue culture cells have not been in agreement. To determine whether there is any validity to the reported effects, established tissue culture cell lines have been exposed to uniformly low, natural magnetic fields under controlled constant environmental conditions. Polyploid cells (HeLa) and diploid cells (Chinese hamster and/or human) have been exposed to magnetic fields of 100 ± 50 gamma, ambient (0.5 ± 0.1 gauss), 400, 500, 600 and 1200 gauss fields each with a measured gradient of 20 gauss/cm. The cells were grown in Eagle's Earle's media and 10 per cent newborn calf serum with 100 units/ml Penicillin and 100 μg/ml Streptomycin in milk dilution bottles under constant temperature of 37° ± 1°C. Enough cultures were grown in each magnetic field so that at least four tubes were removed daily for four days. Cell counts were made by an electronic cell counter. Each culture had an initial inoculum of 50,000 cells/ml.

Daily cell counts taken from days one through four revealed no significant growth difference in the experimental cultures versus the controls. Extensive studies in the 1200 gauss field have been reported elsewhere (*Nature* 202:717, 1964). After four days' growth, control tubes' cell count range was 1.2-2.2x 10^5 cells/ml; in the 400 gauss field, the cell count range was 1.4-1.7x10^5 cells/ml; 500 gauss field, cell count range 1.5-2.1 x10^5 cells/ml; and in the 600 gauss field, the range of cells in the count was 0.7-1.3x10^5 cells/ml. In the shielded field of 100 gamma, the cell count range was 1.2-2.1x10^5 cells/ml.

From these data, magnetic fields do not seem to exert any effect upon the growth of cells in tissue culture. However, the 600 gauss field is suspect in that there seems to be a tendency toward growth inhibition. This aspect is being further investigated by additional studies in 600-900 gauss magnetic fields.

Effects of Hypohydration on Work Performance, Psychomotor Performance and Tolerance to G_z in Man.

JOHN E. GREENLEAF, Ph.D., and MILTON MATTER, JR., M.D., NASA Ames Research Center, Moffett Field, California.

A study has been undertaken at Ames Research Center to assess the effect of various states of hypohydration on work performance, psychomotor performance, and $+G_z$ acceleration tolerance. Hypohydration is defined as diminished water content in relation to osmotically active substances.

Hypohydration was achieved in nine subjects by restricting the daily water intake while maintaining caloric and electrolyte intake by a controlled diet. Experiments were conducted with subjects normally hydrated and approximately 2 per cent and 6 per cent hypohydrated. The subjects were given a battery of work performance and psychomotor tests; and were centrifuged in the positive G_z direction using loss of central vision as an end point. Blood volume, total body water, and serum and urine electrolytes were measured.

Dehydration has occurred on previous space flights due to a combination of reasons. With the advent of longer duration space flight followed by a hypergravity condition on reentry, an evaluation of pilot capability when hypohydrated is necessary.

Modified and Ventilated Divers' Wet Suit as a Potential Substitute for the U.S. Navy Anti-Exposure Assemblies as Used in the S-2 Aircraft.

CDR. WALTER L. GOLDENRATH, MSC, USN, LT. NATHAN BARRETT, MC, USNR, and LT. RONALD L. HANSEN, USNR, Medical Department, Naval Air Station, San Diego, California.

The Navy's use of the dry type anti-exposure garments has met with a high degree of unacceptability by the Naval Aviator because of their bulk and the difficulty in maintaining their integrity. An attempt was made to show that an individually fitted and otherwise modified divers' wet suit when properly ventilated can be worn comfortably and safely by pilots and aircrewmen. Six flights were flown at moderate (70 ± 3) air temperature and high ambient air temperature (90 ± 7 degrees) lasting 4-5 hours per flight and continuous recordings of skin, core and ambient air temperatures were obtained. Two of the flights were flown in conventional flight gear to provide a basis for comparison. In addition the suit was tested in an arctic tank of a water temperature of 30°F. and air temperature of 20°F.; additionally, studies were performed to compare the volumes and degree of restriction of the wet suit and the Mark V anti-immersion garment with conventional flight gear. Results showed that the modified ventilated wet suit was a comfortable garment for prolonged flights and gave skin and core temperatures comparable to conventional flight gear even at high ambient air temperatures. In cold water the wet suit with neoprene booties and gloves permitted the subject to remain immersed for nearly two hours without undue discomfort and no physiological compromise. The wet suit offers a 50 per cent reduction in bulk compared with the Mark V, and the degradation in mobility in the ventilated wet suit was less than 5 per cent whereas in the ventilated Mark V assembly it was greater than 12 per cent. This information, coupled with the ease of maintenance, and its ability to protect the wearer even if torn should make the divers' wet suit a subject for further investigative effort to incorporate this concept into the survival equipment of the Naval aviator.

The Effect of Temporary Hearing Loss on USAF Band Member.

MAJ. PAULL R. HANSON, USAF, MC, 821st Medical Group, Ellsworth AFB, South Dakota.

It has been noted that band members have poor tone discrimination for varying periods subsequent to flight. This impairment varies with the type of aircraft, duration of the flight, and instrument played. It is postulated that temporary hearing loss due to noise trauma is responsible for this defect.

The paper evaluates noise levels in various aircraft. These noise levels are correlated with tone discrimination for various instruments in the band. Results show that noise trauma temporarily impairs tone discrimination. Recommendations are made for periodic hearing evaluations. Earmuffs and/or ear plugs should be issued to band members. In no other profession is disability greater due to hearing loss.

Plasma Free Fatty Acid Changes in Man During Acute Cold Exposure and Nicotinic Acid Ingestion.

CAPT. PETER G. HANSON, USAF, MSC, ROBERT E. JOHNSON, M.D., and GEORGE ENGEL, B.S., Human Environmental Laboratory, University of Illinois, Urbana, Illinois.

We have shown previously that acute cold exposure produces a significant increase in plasma free fatty acids (FFA) in human subjects. Several investigators have demonstrated that orally ingested nicotinic acid suppresses plasma FFA concentration in fasting humans. Our present research was designed to observe the effect of acute cold exposures on plasma FFA after oral ingestion of nicotinic acid. Four healthy male subjects (21-25 yrs.) were studied in paired cold exposure and control periods for a total of twenty experiments during June and July, 1964. The conditions of cold exposure were: semi-nude for 100 minutes at 2°C., followed by 240 minutes of recovery at 24°C., lightly clothed. Control periods covered an equal time span at 24°C. All experiments were conducted in a fasted state with water *ad. lib.* Nicotinic acid (200 mg *per os*) was taken 10 minutes prior the beginning of the periods for which it was scheduled. In addition to plasma FFA, the following measurements were made: plasma glucose, plasma total ketones, urinary vanilmandelic acid, urinary total ketones, and respiratory energy metabolism. Our data show that nicotinic acid strongly suppresses ($P < .01$) plasma FFA concentration during acute cold exposure in contrast to the usual increase in plasma FFA which is observed with cold exposure while fasting. This action significantly reduces the availability of FFA as a metabolic substrate at a time of increased requirement for energy metabolism. There is a suggestion that gross oxygen consumption is concomitantly reduced during cold exposure periods following nicotinic acid ingestion.

Aspects of Oral Hygiene and Emergency Dental Care for Long Term Space Flight—Stomatologic Evaluation—USAF-NASA Nutrition Study.

LT. COL. JACK L. HARTLEY, USAF, DC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The accomplishment of proper oral hygiene on extended space flights will be a physiological and psychological problem. The candidates for space flights are presently very adequately screened for medical defects. Such procedures as are necessary to minimize dental emergencies must be provided. It can be stated that in the average stomatologic system, conditions routinely exist that can and will, under the complexity of environmental conditions to be encountered in space flight, cause an acute exacerbation of oral disease to such an extent as to seriously limit the performance of the space crewman unless an active, effective program of preventive oral hygiene is maintained before and during the mission. Subjects in simulated space flights in studies of the precise caloric, protein, and water requirements are placed on various oral hygiene procedures. They are evaluated for pre- and post-flight stomatologic status. Results have produced definite contraindications for certain procedures. Recommended procedures with clinical results are discussed. An emergency oral medicine "buddy care" kit is presented.

Phase Shifts of the Human Circadian System and Performance Deficit During Periods of Transition.

G. T. HAUTY, Ph.D., and T. ADAMS, Ph.D., Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

At periodic intervals throughout the biological day, assessments were made for a week prior to intercontinental flight yielding a reference of biological time set to the environment of origin, for 2 weeks at the temporally displaced environment of destination which encompassed the period of transition for the "primary" phase shift, and for a week following return to the environment of origin which provided a period of transition for the "back" shift. Assessments made included rectal temperature, heart rate, respiratory rate, palmar evaporative water loss, urinalysis, reaction time, decision time, critical flicker-fusion, subjective fatigue and well-being, and intellectual facility. The intercontinental flights included East-West and West-East with each crossing 6 or more time zones. From the considerable volume of data obtained, there are apparent certain general findings which possess practical implications and which will be reported. In brief, these pertain specifically to such phenomena as the lag time for a shift in phase of a given biological parameter, the degree of synchronization in the shifting in phase of different parameters, and performance deficits associated with these phase shifts. Also to be reported are the differential characteristics of these phenomena manifested during the two different phase shifts, primary and back, and, additionally, the extent of inter-individual differences.

Enzyme-Isoenzyme Measure of Radiation Exposure.

E. J. HAWRYLEWICZ, Ph.D., and W. H. BLAIR, B.S., Life Sciences Research Division, Illinois Institute of Technology-Research Institute, Chicago, Illinois.

These experiments are concerned with the change in selected serum enzyme and isoenzyme concentrations as a function of chronic exposure to gamma radiation. The objective is to determine whether an unique biochemical change occurs as a function of radiation exposure and can be utilized for dosimetric indices.

A group of 40 rhesus monkeys was divided into four equal groups receiving the following continuous exposures: 0 r/wk, controls; 1 r/wk; 10 r/wk; and 100 r/wk. The enzyme and isoenzyme systems examined were lactic dehydrogenese (LDH), alkaline phosphatase (AP), and leucine aminopeptidase (LAP). Each of these serum enzymes and their isoenzyme patterns were obtained over a period of 30 weeks at the following time intervals: 0, 3 days, and 2, 4, 8, 16, 20, 24, and 30 weeks.

The data demonstrated a statistically significant increase in LDH activity after 3 days and 2 weeks of exposure at 100 r/wk. Further exposure resulted in recovery and ultimately (after 16 weeks) a highly significant (0.1 per cent level) depression of serum LDH. A LDH isoenzyme shift to bands 1 and 2 and a concomitant decrease in bands 4 and 5 also occurred. These results are significant after 20 weeks of exposure. LDH isoenzyme bands 1 and 2 are concerned with aerobic oxidation, and conversely, bands 4 and 5 with anaerobic oxidation. These data are interpreted as cellular metabolic changes induced by radiation.

Serum isoenzyme changes are a manifestation of tissue alterations. Skin was extracted, and the resulting LDH isoenzyme patterns indicated a marked shift from normal anaerobic metabolism to aerobic.

No significant trends were noted with the other enzyme systems.

Current studies are determining the minimal exposure which will induce skin and other tissue LDH isoenzyme pattern alterations. The utilization of the isoenzyme system provides a means of relating gross serum changes to cellular metabolic effects induced by radiation.

Supported by School of Aerospace Medicine, Contract No. AF 41(609)-2021.

Meteorologic Factors in the Fallout of Pollens and Molds.

HERMAN A. HEISE, M.D., Milwaukee, Wisconsin.

This presentation, composed of a movie and an accompanying talk, demonstrates the effects of city heat and smoke, of clouds and fog, of bodies of water and other terrain factors, upon the incidence and distribution of fallout. Although the work was done primarily with pollens and molds, the implications for Civil Defense are obvious. The basic research for this work consisted of the collection of air samples from multiple altitudes, under the effects of the above-mentioned factors.

This subject was presented originally at the Aerospace Medical Association Meeting about eight years ago, but since that time the movie has been prepared, and much additional data is now available.

The Effect of Anterior Intercostal Nerve Block on Thoracic Pain Associated with G_Z Vibrations.

CAPT. JOHN H. HENZEL, USAF, MC, MAJ. NEVILLE P. CLARKE, USAF, VC, and CAPT. GEORGE C. MOHR, USAF, MC, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Sinusoidal vibration directed parallel to the vertebral column in the seated position ($1G_Z \pm g_Z$) produces chest pain which limits the amplitude of acceleration tolerable in the four to eight cycle per second frequency range. It is usually described as a localized (occasionally radiating) substernal or subcostal discomfort that rapidly intensifies with increasing vibration amplitude. There has been concern whether cardiac-great vessel and/or mediastinal strain is of sufficient magnitude during vibration to be the source of this pain. This study tested the hypothesis that such thoracic pain may be of anterior chest wall rather than thoracic visceral origin. Subjects were exposed to six cycle per second vibration of increasing amplitude and the acceleration required to induce perceptable chest pain was considered as the threshold level. Two series of such determinations (randomly ordered) were made in each of 10 subjects. In one set of tests, bilateral local anesthetization of intercostal nerves two through six utilizing xylocain preceded vibration. In the other series solely intradermal infiltration (but at similar sites) was accomplished resulting in grossly similar cutaneous experiences for both blocks. With intradermal infiltration alone (no deep intercostal injection) all subjects experienced typical chest pain and eight of ten noted onset at or below 2.0 G. With actual intercostal nerve block six of ten subjects experienced no chest pain up to the maximum 2.5 G exposure which was established for safety purposes. Nine of ten subjects had increased thresholds of chest pain with intercostal infiltration. These results support the hypothesis that the chest pain produced by sinusoidal vibration at these amplitudes has its origin in anterior chest wall and not deeper structures.

Effects of Gas Embolism upon the Pulmonary Circulation.

Wg. Cdr. P. Howard, RAF, Sqn. Ldr. D. H. Glaister, RAF, and Air Cdr[2]. W. K. Stewart, RAF, RAF Institute of Aviation Medicine, Farnborough, England.

The introduction of gas into the venous side of the circulation results immediately in a considerable increase of the pulmonary arterial pressure, and of vascular resistance in the lung. The effect is largely independent of the rate at which the gas is injected, and of the injection site.

It does not depend upon the integrity of the vagi, or of the sympathetic supply. The degree of the pulmonary hypertension is, however, related to the solubility of the injected gas.

Radar Hazards Evaluation—Concepts and Criteria.

Joe W. Howland, M.D., and Sol M. Michaelson, D.V.M., University of Rochester School of Medicine and Dentistry, Rochester, N. Y., and Griffiss AFB, Rome, N. Y.

There is a paucity of information on authenticated effects of microwave exposures among radar workers in the U.S.A. The Soviets report effects occurring under industrial conditions of operation where individuals may be exposed to microwave irradiation over a period of time. Similar observations have been alluded to in this country but have not been reported. The main factors which influence the response of individuals exposed to microwaves are the frequency or wavelength, duration of exposure, duty cycle of the apparatus, and environmental conditions during the exposure such as temperature, humidity, and air currents. There is little doubt that as more elaborate microwave radiating equipment in developed both for civilian and military use and as the power output of these devices is increased, our concept of the biological potentials of this energy may have to be revised. In order to evaluate the microwave radiation hazard problem and to establish safe tolerance levels, the U. S. Air Force requested our laboratory to detect and characterize the damaging effects of both acute and chronic nature caused by microwave exposure, establish a tolerance or safe exposure level for individuals working with microwave generators, and establish, if possible, a biological effect in terms of timed exposure at specific power densities. Any effects which we have described are for the most part insepararable from responses which could occur under thermal stress. Certain findings have been made, which, because of their subtle nature and questionable relationship to thermal effects must be carefully evaluated. The early and long term significance of these findings are discussed. Modification of the ionizing radiation response, an ancillary aspect of our microwave hazards evaluation program, has significant possibilities. For a complete understanding of the biologic effects of microwaves with hazards implications, the suggestive changes noted by this laboratory as well as others should be explored and evaluated.

A Preliminary Report of a Wide Range Vectorcardiogram.

George F. Humbert, Jr., M.D., and Clifford C. Phipps, U. S. Naval Missile Center, Point Mugu, California.

The necessity for early detection of latent and progressive coronary artery disease in the aviator is obvious. This capability, indeed, becomes indispensable when one considers the statistics of morbidity and mortality on the American male in the age group of experienced aviators. It has been shown that presently accepted methods of coronary evaluation are deficient when correlation of actual arteriosIcerotic episodes and available individual data is attempted. This paper will present an approach to this problem. It is anticipated that the proposed technique will augment the resolution of that area between presently detectable pathology and the actual status of coronary degeneration.

It has been demonstrated that the presence of ischemic pathology alters the bio-electric signature of the heart in several ways. It appears that one variation results from the generation of additional and higher frequencies superimposed on the basic electrical configuration. Present clinical techniques used in the recording of myocardial activity fail "to see" these electrical aberrations.

This study will summarize an approach to the acquisition, presentation and analysis of these low amplitude, high frequency energies. It includes, (a) a description of the acquisition system, (b) the use of quantitative presentation (frequency versus amplitude) and (c) the analytical relationship of "normals," aviators and grossly pathological individuals.

An attempt will be made to relate a quantitative spectrum of high frequency energies with a gross spectrum of arteriosclerotic pathology. Emphasis will be directed toward that portion of this relationship in which significant high frequency readout occurs in the face of negative findings from presently used aviator coronary evaluation.

A Factorial Study of Immersion Diuresis and Its Inhibition by Positive Pressure.

Capt. Noel C. Hunt, III, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

This study was sought to further define the nature of a water immersion diuresis and to attempt to counterbalance the negative pressure breathing (NPB) inherent to water immersion with properly applied positive pressure. In this manner, a simulated weightlessness environment is presented in which water pressure counterbalances the usual hydrostatic gradients of the vascular system, without the artefactual NPB element.

A panel of subjects has been submitted to a factorial analysis to compare urine volume and composition during routine activity, recumbency, and water immersion (semi-supine with head-out). A continuous-flow respiratory system using weighted spirometers was evaluated for (a) absence of intrinsic diuretic stimuli at zero pressure, which have been noted even in low resistance respiratory equipment, and (b) ability to produce antidiuresis at positive pressures. These standards were attained. Measurements of the negative pressure imposed by head out immersion were made.

Current analysis includes four subjects, with an anticipated total of ten. The subjects were dehydrated and submitted to six hours of the various regimens, with urine collected hourly for volume and composition. Using the urine of routine activity as control, the volumes during recumbency and immersion increased 230 per cent and 354 per cent, respectively. Application of 15 cm H_2O respiratory pressure to immersed subjects reduced the volume to 254 per cent. Sodium values, presented as above were 204 per cent and 294 per cent, respectively, returning to 199 per cent during positive pressure application. Comparison of recumbency and immersion urines reveals a qualitatively similar composition, the implication of which will be discussed. Absolute amounts of creatinine excretion revealed minimal differences between treatments, in contrast to previously reported findings; standard GFR studies are being initiated. Finally, comparison of immersed subjects with and without respiratory counterpressure will be presented.

The Relationship Between Past History of Motion Sickness and Attrition from Flight Training.

Ens. Charles W. Hutchins, Jr., MSC, USNR, and Lt. Robert S. Kennedy, MSC, USN, Naval School of Aviation Medicine, Pensacola, Florida.

In a previous study twelve items in a Motion Sickness Questionnaire (MSQ) were found to predict degree of canal sickness encountered by 100 subjects during a 7.5 RPM run on the Pensacola Slow Ration Room. These items were administered to a group of 1,000 flight students to determine whether past history of motion sickness as measured by this questionnaire is related to subsequent success in flight training. A significant (.05 level) relationship is shown. The Wherry-Doolittle method of test selection indicates that the addition of the MSQ score to current predictor variables increases significantly the validity of prediction. The predictive validity of the individual items is also discussed.

Development of Automatic Controls for a Two Gas Atmospheric Supply System.

J. K. JACKSON, Missile and Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, California.

A system for controlling and metering the supply of atmospheric gases to a manned spacecraft has been built and operated as a part of the Manned Space Cabin life support system engineering test program. This system provides a suitable inert diluent gas to hold cabin pressure at the required value, making up for cabin leakage, and supplies oxygen as required by leakage and crew consumption.

The system was designed to support a 4-man crew in a cabin of approximately 3,000 cubic feet volume with a 50-50 oxygen-nitrogen atmosphere at 7.0 psia cabin pressure. The system consists of parallel channels for control of oxygen and nitrogen flows. Oxygen partial pressure is sensed by a polarographic sensor and oxygen flow is controlled to maintain a preselected setpoint. Chamber total pressure is sensed by a strain gage transducer and nitrogen is added as required. Each channel of the system operates on a pulse basis in which gas at regulated pressure is metered by a fixed orifice for a fixed time duration. Pulse duration is 10 seconds in each channel. Proportional control action is achieved by modulating pulse frequency proportional to error signal.

Each pulse introduces a fixed quantity of gas during operation in the manned simulator. Pulse counters were provided to indicate total flow of each gas. The control system is adaptable to both gaseous and subcritical cryogenic storage systems. The pulse modulated signal may also be utilized in the cabin leak detection system.

The Effect of Weightlessness Upon the Normal Nystagmic Reaction.

MARGARET M. JACKSON, M.S., and M/SGT. C. W. SEARS, USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Twenty subjects were exposed to Coriolis acceleration plus weightlessness during parabolic flight. Continuous electronystagmographic recordings and infra-red motion pictures of eye movements were obtained before, during, and after each rotational period. Coriolis and aircraft accelerations were also recorded. Control tests were conducted on the ground and during flight at 1 and 2 G_z. The traces obtained were evaluated visually. Each subject experienced rotatory and postrotatory nystagmus during weightlessness, and the response was essentially the same as at 1 and 2 G_z. Weightlessness produced no significant change in the normal nystagmic reaction. The data of this experiment suggest that utricular reinforcement of discharges from the semi-circular canals is not essential for elicitation of vestibular nystagmus.

A Treadmill Exercise Test in the Aeromedical Evaluation on Flying Personnel.

LT. COL. ROBERT L. JOHNSON, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Lack of physical exercise has been incriminated as one factor in the increasing incidence of coronary heart disease in modern cultures. Recently Air Force flight surgeons have attached increasing importance to the desirability of high levels of physical fitness in the Air Force flying population. Although physical fitness is composed of many elements and is notoriously difficult to quantitate, the School of Aerospace Medicine has for several years attempted to incorporate an assessment of physical fitness into its aeromedical evaluations of flying personnel. A standardized treadmill exercise test has furnished the primary input into this assessment. While total treadmill performance time furnishes an index of over-all physical fitness, other information which relates to cardiac performance and has implications regarding coronary blood flow can be derived from the measurement of oxygen consumption during peak physical exertion. Additional information can be derived from correlations with total body weight and lean body mass. These data in various age groups of USAF flyers referred to SAM because of aeromedical problems, in candidates for special aerospace missions, and in other normal individuals will be presented and discussed.

Optokinetic and Vestibular Influences Upon the Control of Compensatory Eye Movement During Head Rotation in Various Planes.

G. MELVILL JONES, M.A., M.B., Aviation Medical Research Unit, McGill University, Montreal, Canada.

Recent flight experiments revealed serious failure of compensatory eye movements to achieve the angular velocities required for fixation of the retinal image of the outside world during rotational manoeuvres. The following experiments attempted to define the respective parts played by optokinetic (visual following) and vestibular influences and the planes in which they act. The terms yaw ("horizontal"), pitch ("vertical") and roll are used to describe planes of skull and eye rotation as they are with aircraft. Subjects were accelerated on an electronically controlled turntable to a chosen angular velocity which was then maintained constant for 3 minutes and finally decelerated to a standstill. They either had their heads tilted backwards, or sideways, at 45° to the vertical axis of the turntable. Thus, with eyes looking at an appropriate stationary optokinetic stimulator, they were simultaneously exposed to equal angular velocity stimuli in the planes either of yaw and roll, or of yaw and pitch. Measurement of compensatory eye angular velocities in the relevant planes with a movie-photographic technique revealed very poor optokinetic following in the roll plane and hence complete dissociation of oculomotor responses in yaw and roll. In yaw and pitch the components of eye angular velocity were always equal to one another, despite failure (often gross) to reach the required numerical value. This implies that in this case the plane of ocular compensation always tended to parallel that of the rotational stimulus, despite failure to achieve visual fixation. A number of basic and clinical implications are adduced.

The Use of Two Qualitative Indices as Predictors of Success in Flight Training.

ENS. PAUL R. JEANNERET, MSC, USNR and ENS. CHARLES W. HUTCHINS, JR., MSC, USNR, US Naval School of Aviation Medicine, Pensacola, Florida.

This study investigates two qualitative indices (officer rank, and procurement source) as predictors of subsequent success in flight training.

These two indices were evaluated separately. In the investigation of rank 1,636 officers were used; 1,417 non-officers and 755 officers were used in the study of procurement source.

The records of these men were examined for their scores on the selection tests, their Pre-Flight performance grades and the qualitative variable under study. These indices, together with two criterion measures (over-all attrition and voluntary withdrawal) formed an intercorrelation matrix. From the correlation coefficients of this matrix the Wherry-Doolittle method of test selection was used to determine if the qualitative variable (treated as a dichotomy) increased the validity of predicting success. This procedure was followed before the student began Pre-Flight School and again after this training was completed.

Both indices increased significantly the validity of predicting over-all attrition and voluntary withdrawal at both stages of training.

A general approach to the isolation of valid quantitative predictors is discussed. Briefly this approach consists of testing readily available qualitative information in the manner of this study. Those qualitative variables selected as predictors are subjected to a detailed analysis to determine the manner in which successful and unsuccessful students differ. These distinguishing factors are quantified and themselves tested as predictors. This approach also holds promise as a method of detecting and eliminating those factors which contribute to high attrition rates.

Prediction of Nearest Safe Distances for Thermal Radiation of Nuclear Weapons.

MAJ. W. C. KAUFMAN, USAF, and LT. JAMES C. PITTMAN, JR., USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The time-distance-thermal energy relationships for a variety of nuclear weapons have been plotted from Atomic Energy Commission data. These relationships have been combined with data from our experiments into a nomogram to predict nearest safe distances from special weapons. Human skin temperature increases were measured simultaneously with a radiometer, surface thermocouples and intradermal thermocouples during exposure of the dorsum of the hand to intense thermal radiation. First degree burns were common and second degree burns have occurred. Biological data were then plotted along lines of constant irradiance so that they apply to devices ranging in yield from 0.020 to 20 megatons. The amount of energy and period of emission of thermal radiation and distances at which: 1) pain, 2) first degree, and 3) second degree burns will occur are shown graphically; for example, for a 5 megaton device, the emission of thermal radiation will be 0.80 complete in 17 seconds, a maximum skin temperature of 45° C, for unprotected man, will occur at 30 miles and pain will be experienced. First degree burns will occur at 26 miles and second degree burns at 18 miles. The attenuating effects of plate glass, plexiglass and aircraft windshield have also been determined. An aircraft windshield will attentuate the energy to the degree that for a 5 megaton device, pain should not be experienced by a pilot beyond 20 miles.

Dispersion of Respired Gas in Manned Space Enclosures.

D. A. KEATING, K. WEISWURM, G. W. FILSON, C. M. MEYER and I. H. LANTZ, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The purpose of this paper is to present conclusive findings of the movement and dispersion of respired gas during weightless flight in manned space enclosures.

The effects of gaseous dispersions produced only by respiration and diffusion are reported. This is the condition that exists in manned spacecraft without forced atmosphere movement during weightless flight for a sleeping or restrained astronaut.

The techniques of dimensional analysis and model theory have been used to provide experiments in the earth laboratory which completely represent the dispersion of respired gas in weightless space enclosures for various atmospheres. Inhalation flow patterns have been established which demonstrate that atmosphere gas is inhaled from regions in the immediate vicinity of the nostrils and mouth. Dispersion patterns have been determined for singular and multiastronaut occupancy in finite and infinite enclosures for both oral and nasal respirations.

Results of actual manned sealed environment experimentation without forced atmosphere movement during weightless flight are presented. This experimentation was performed in a sealed capsule on the modified USAF KC-135 aircraft for weightless flight.

The findings in this paper give evidence that an astronaut will not poison himself because of lack of atmosphere movement. The exhaled carbon dioxide is dispersed within manned space enclosures to concentrations well within safe ranges primarily by jet-plume momentum effects.

Dynamic Counterrolling of the Eye in Normal and Labyrinthine Defective Subjects.

CAPT. ROBERT S. KELLOGG, USAF, CAPT. ASHTON GRAYBIEL, MC, USN, and EARL F. MILLER, II, Ph.D., Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, and Naval School of Aviation Medicine, Pensacola, Florida.

Dynamic counterrolling measurements were obtained on ten normal and five labyrinthine defective subjects. The subject, seated in a motorized chair, was rotated 360 degrees about his anteroposterior axis at the level of the canals and at a point midway between them. Rotations at rates of 5, 10, 15, 20 and 30 RPM, both clockwise and counterclockwise, were made. Synchronous cameras recorded the eye position and that of the chair with respect to gravity. The photographic image of the iris of the eye was collated with a reference image in measuring rotation. The average repeatability in making the measurement of the given frame was plus or minus five minutes of arc.

The labyrinthine defective subjects showed no characteristic counterrolling response. The normal subjects showed standard counterrolling curves which decreased in amplitude as the rotation rates were increased. There was also a phase shift in response which depended on rate and direction of rotation.

Drinking Water Supplies for Project Gemini Space Flights.

W. W. KEMMERER, Ph.D., NASA Manned Spacecraft Center, Houston, Texas.

The longer space flights of the Project Gemini program require on-board sources of potable water. A review of the sources to meet this requirement is presented, their feasibility evaluated, and the standards required for their use discussed.

Fuel cell water and water condensed in the cabin or suit environmental control systems are discussed as sources of drinking water. The origin of contamination and the methods for their purification are outlined.

The use of water from these sources requires the development of potability standards applicable to manned space missions. The protocol used in the establishment of spacecraft water potability standards is discussed. Microbiological and chemical analysis, animal studies, and human testing are integrated in this program.

The Gemini spacecraft drinking water system is discussed in its relation to the provision of a high purity water for missions of up to 14 days.

Symptomatology Under Storm Conditions in the North Atlantic in Control Subjects and in Persons with Bilateral Labyrinthine Defects.

LT. R. S. KENNEDY, MSC, USN, CDR. R. C. MCDONAUGH, MC, USN, CDR. F. D. BECKWITH, MC, USN, and CAPT. A. GRAYBIEL, MC, USN, Naval School of Aviation Medicine, Pensacola, Florida.

Thirty-one persons were exposed to thirty-foot waves ($>45°$ roll and >2 "g" units scend) in a round-bottomed sea-going tug for 24 hours. All experience physical discomfort and the great majority were afraid. Of the ten subjects with labyrinthine defects, none manifested typical symptoms of motion sickness; eight were symptom-free and one each reported "gas in the stomach" and "constriction in the throat." Three of the twenty-one control subjects exhibited slightly suppressed function of the semi-circular canals on one or both sides; two of these were slightly sick and one vomited. Of the remaining eighteen, fourteen vomited and four were moderately sick. The implications of these findings in terms of semicircular and otolith functions are discussed.

Repeated or Continual Measurement of Cardiac Output by a New Thermodilution Method Applicable to Telemetry During Space Flight.

HASSAN H. KHALIL, M.D., Ph.D., Naval School of Aviation Medicine, Pensacola, Florida.

The present work is a modification of a previously reported method which allows repeated or continual measurement of cardiac output at reast or during exertion. It consists of using a single catheter passed via a peripheral vein through the heart and the pulmonary artery. A high frequency electric heater is wound around a radio-opaque cardiac catheter 0.5 m.m. in diameter. Two sensitive temperature transducers are located near the surface of the catheter at equal distances from the heater. The distal temperature transducer measures the mean temperature of the blood flowing through the pulmonary artery while the proximal one acts as its reference. The heater which should be in the right atrium or right ventricle is turned on for a given period of time so that a predetermined amount of heat energy is transmitted into the blood at a continuous rate. The temperature differential between the two transducers should then indicate the heat build up in the pulmonary artery.

This minute rise in temperature which ranges from 0.02° to 0.08° C is inversely proportional to cardiac output. The method is analogous to the continuous dye dilution method and is based exactly on the same principles except that high frequency power, converted into heat energy, is used instead of dye. This method has a major advantage over the dye method, however, in that the body acts as a very large heat "sink" so that there is almost no recirculation problem.

Preliminary observations on a circulation model indicate that the experimental values obtained are very close to the calculated theoretical curve. This miniaturized radio-opaque cardiac catheter which is only 0.5 m.m. in diameter, should be suitable for obtaining the right cardiac output in the squirrel monkey as well as the carotid and coronary blood flow in large animals. The advantages of this simple procedure for obtaining hemodynamic measurements during space flight are apparent.

Helicopter Rotor Blade Injuries. MAJ. FRANK W. KIEL, MC, USA, Armed Forces Institute of Pathology, Washington, D. C.

In helicopter accidents, 6 per cent of the fatalities are bystanders struck by a rotor blade.

The files of the United States Army Board for Aviation Accident Research, U. S. Naval Aviation Air Safety Center, Office of Deputy Inspector General of the Air Force and the Civil Aeronautics Board contain reports on 17 deaths due to rotor blade injuries.

Civilian helicopters were involved in over half of the 17 fatal cases, typically the small utility helicopter with a main overhead rotor and a smaller anti-torque rotor on the tail. In the earlier years, spectators were the usual victims, but ground crewmen and disembarking passengers are the persons being struck more commonly nowadays. In 8 instances, it has been the small anti-torque rotor which has been the wounding agent, while in 6 cases a main rotor has been involved.

Continued vigilance by ground crewmen, repeated warnings to passengers and competent supervision of spectators must be maintained in order to eliminate this completely preventable type of death.

The Influence of Vibrations on Chromosomes. JAMES C. KNEPTON, M.S., Naval School of Aviation Medicine, Pensacola, Florida.

Russian workers have discovered chromosome rearrangements in microspores of *Tradescantia paludosa* which were subjected to the flight factors of their Vostok series of earth-satellite experiments. They stress the importance of vibration as a contributory factor in disturbances of chromatin material during microsporogenesis in *Tradescantia*. This report gives the results of a series of experiments in which cells from various organisms were vibrated at a variety of frequencies, amplitudes, and G forces. The chromosomes that were studied were from microspores of *Tradescantia paludosa* (Clone 3 of Sax), conidia of *Neurospora crassa* (prolineless clock-mutant, FGSC #491), and salivary glands of larval *Drosophila melanogaster* (wild type, Carnegie Institute of Washington, D. C.). The conclusions derived from this investigation are critical to an interpretation of the Russians' findings and to the planning of our (U.S.A.) own exposures of man to unusual conditions and types of vibrations.

Experiments with the Bioelectric Potentials. J. J. KONIKOFF, B.S.M.E., General Electric Company, King of Prussia, Pennsylvania.

Empirical studies were conducted on rats, rabbits, and dogs to define the quantity of electricity obtainable by the direct implantation of dissimilar metallic electrodes. Optimization studies resulted in the selection of the best apparent anatomic site, electrode materials, electrode geometric configuration and area for maximum output. Primary emphasis was placed on deriving a useful amount of dc electricity during long term experiments which resulted in no adverse effects on the host animal.

Results demonstrated that a power output of 308 micro watts under a load of 1,000 ohms at 0.555 volts was attainable using a pair of electrodes made of high speed steel and platinum-platinum black. The electrodes were implanted and sutured on either side of the peritoneal membrane of a rabbit with the plantinum-platinum black dorsal.

Long term experiments (up to 128 days) have been shown the feasibility of the utilization of bioelectric potentials under a continuous drain resulting from a 10K ohs impedence. No tissue damage or other anomalies have been found.

Preliminary application studies have resulted in the operation of tunnel diode and/or transistorized radio transmitters. Using a modulated circuit, it has been possible to transmit a heart beat signal a distance of thirty feet.

This work was supported in part under NASA, contract NAS2-1420.

The Evaluation of Visual Function in Terms of Simple Objective Eye Tests. EMANUEL KRIMSKY, M.D., Brooklyn, New York.

Eye testing is a necessary part of a flight examination. Too often eyes are not inspected while eliciting information about visual responses. As a result, one may overlook the presence of such disqualifying eye disorders as strabismus, nystagmus, diplopia, paralysis, corneal scars, congenital or acquired cataract, and glaucoma.

Relying on simple, portable instruments the author has evolved a plan for an objective study of the eyes to help confirm subjective responses. Such tests can be easily carried out by doctors who do not specialize in the eyes. Devices used or designed by the author include a simple flashlight, a new hand slit-lamp, an eyecup perimeter, a new graded prism-Maddox rod combination, and a modified Prince rule.

Quality Standards for Drinking Water in Space Travel. ROBERT C. KRONER and HERBERT E. STOKINGER, Division of Water Supply and Pollution Control U. S. Public Health Service, Cincinnati, Ohio.

Standards for drinking water to be used in space travel need not be based on commonly accepted criteria which are concerned with esthetic properties or toxicity resulting from long term exposure. The usual stringent criteria of such constituents as iron, fluorides, cyanides, various trace metals and other contaminants may be greatly relaxed or completely ignored. Instead, the space water standards should consider the necessity for bacteriological sterility, freedom from exotic organic materials, low concentrations of cardiac and renal acting ions, pre-conditioning of astronauts to the reclaimed water. Quick and simple tests to establish partial acceptability may include conductivity, pH, odor, turbidity, taste, color, chlorides and sulfates. Analytical data from recovered urine and condensate water is presented.

Lung Change Resulting from Prolonged Exposure to 100% Oxygen at Pressures Below Atmospheric. GEORGE H. KYDD, Ph.D., Aviation Medical Acceleration Laboratory, Johnsville, Pennsylvania.

Atelectasis and pulmonary edema are familiar manifestations of oxygen toxicity and both may be considered reversible. Fluid accumulation in oxygen toxicity has also been observed around the pulmonary blood vessels but the reversibility of this process has not been determined. To answer this question we have examined the lungs of Cesarean-delivered Charles River rats exposed to pure oxygen at 10 psia continuously for four weeks beginning at nine weeks of age. In addition to the alveolar hyperemia reported by others, we found that the perivascular areas that would appear fluid filled in animals exposed to O_2 atmospheric pressure, were evident after these exposures but now contained a matrix of fibrous tissue interspersed with leucoytes and were free of fluid. Thus the perivascular areas

were non-functional regarding gaseous exchange. The walls of the vessels were so enlarged (by swelling or hypertrophy) as to approach on the vascular lumen.

Effect of Head Movements in Various Planes on Performance During Rotation.

J. M. LAGERWERFF, M.D., B. D. NEWSOM, Ph.D., and J. F. BRADY, B.S., General Dynamics/Astronautics, San Diego, California.

The trunnioned cabin on the Manned Revolving Space Station Simulator at Astronautics offered the opportunity to test the concept that head rotation about an axis parallel to the axis of rotation in a space station will cause minimum disorientation due to coriolis effect. The problem has been treated theoretically but facilities were not available to test the concept quantitatively. Revolving the simulator with an inclination of 45° and an RPM of 12.2 aligns the resultant centrifugal gravity vector normal to the floor. Subjects were then inclined at 45° to the floor and oriented so they faced, (1) toward the axis; (2) away from the axis; and (3) in the direction of motion. When they rotated their head from side to side in each position, the axis of rotation was: (1) parallel to the spin axis; (2) perpendicular to the axis; and (3) at 45° from the axis. Performance records, response time, and head rotation rates show that single head movements about an axis parallel to the spin axis causes the least degredation in the simple performance of pressing the correct button to correspond with a display symbol. It was also observed that certain types of repeated head movements during rotation ddi not cause the anticipated problems even when made perpendicular to the plane of spin. This study supports the theoretical arguments and is significant to space station design as it helps define arrangement of displays and controls within a revolving system.

The Analysis of Qualitative Data in the Biological Sciences.

ENS. NORMAN E. LANE, MSC, USNR, Naval School of Aviation Medicine, Pensacola, Florida.

The development of computers has made possible the analysis of the complex interrelationships of relatively large numbers of variables. In order to use regression or multiple correlation techniques, the data from these variables must be meaningfully quantified. The raw data in medical and biological studies, however, are often expressed as categories (such as diagnoses) or in purely qualitative form (such as the presence or absence of a symptom).

This paper describes a method of converting such categorical or qualitative data into a series of so-called "pseudo-variables," which permits their inclusion in correlational analysis. Examples illustrate the procedure are applied to a study of the relationships of occupation and cholesterol level. Additional applications are suggested.

A Virtually Continuous Measurement of Human Systolic and Diastolic Blood Pressure Transients Without Direct Arterial Puncture.

MICHAEL T. LATEGOLA, Ph.D., CHARLES BARNARD and HILEY HARRISON, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma.

The measurement of human systolic and diastolic pressure transients via direct arterial puncture is both unpleasant and potentially dangerous. Although the measurements of such pressure transients is always desirable in experimental protocols involving circulatory assessment, the potential hazards of direct arterial access discourage the general use of this approach. Under "steady-state" conditions, the conventional, auscultative, cuff-method is useful allowing up to four reasonable systolic and diastolic determinations per minute. Any increased frequency in this type of determination over prolonged periods may lead to experimentally undesirable limb ischemia with concomitant discomfort. The system to be described here has two components: one measures only the systolic pressure with a digit-cuff and pulse-sensing device and the other measures only the diastolic pressure with a conventional, auscultative arm-cuff device. Both components are cycled automatically allowing maximally a three-second interval between measurements of the former and six seconds for the latter. The accuracy of these pressure determinations resembles those of conventional auscultative methods. Classical blood pressure transients, such as those caused by standard respiratory maneuvers, are readily demonstrable. Current and projected use of this system in flight-related human-testing will be discussed.

An Investigation on the Subjective Effects of Time Changes on Flying Staff in Civil Aviation.

J. LAVERNE, M.D., E. LAFONTAINE, M.D., and R. LAPLANE, M.D., Service Medical d'Air France, Paris, France.

The psychological effects of rapid changes of time zones are responsible for part of the occupational fatigue of flying staff in civil aviation. The authors have attempted to establish the importance of the problem by means of an investigation involving 312 members of flying staff from the North Atlantic section of the French National Airline. Bed-time hours, duration and quality of sleep, disturbances in nutrition and digestive functions were analyzed, before, during and after flights from France to America and back. Seventy-eight per cent of the subjects suffer more or less from time changes; mainly sleep disturbances were noted. Almost 30 per cent require at least three nights rest to recover normal sleep. On their arrival in America, most young subjects adopt local time off hand. As they gain age and experience, the older subjects remain more willingly at the time of the country of origin during their stay in North America. Thus they prefer shorter stays which make it easier for them to keep the French time and to readjust themselves on their return. As a general rule, younger subjects request a longer rest at the port of call. In determining flying staff work loads, changes in time zones should be taken into consideration in the form of a ponderation factor assigned to flying hours.

The coming of supersonic transport aircrafts should enable crews to accomplish the return trip on the same day and therefor eliminate the drawbacks of time changes.

Water Handling in the Absence of Gravity.

MARTIN MACKLIN, TRW Equipment Laboratories, Cleveland, Ohio.

The prosaic problems of water removal in humidity control water separators, water flow control in showers, and clothes washing is rarely treated in the literature. These areas present significant theoretical and practical problems in projected space vehicles, since most familiar water handling devices rely heavily on gravitational forces. In the absence of these forces two approaches for air-water separation have been studied—create an artificial centrifugal force field with rotation or use static impingement separation. Examples of the former include cyclone separators and rotating vaned separators. The latter types include sponge and wick separators and the recently developed packed bed porous plate water separator. The statis separators are particularly attractive since they require a minimum of power and have greater inherent reliability.

All of these devices find application in personnel washing units. However, showers and personnel washers have the added problem of requiring positive control of water flow in a zero gravity field.

A clothes washer similarly requires a novel approach. Water should completely fill the space vehicle washing machine. Then if the machine is made of an elastomer it may be agitated externally.

All of these water handling problems deserve to be dealt with in the literature and this paper will attempt to provide a much needed discussion of the problems and proposed solutions. Where appropriate, analytical details will be given, especially with reference to water separators. Water purification will not be discussed. However, since the purity of water depends on its prior use, methods necessary for ease of purification or possibilities of use or re-use of water without purification will be presented. This would include for instance, data on the purity of water collected as air conditioning condensate and use of nonsudsing detergents.

A New Miniaturized Seven-Channel Personal Telemetry System.

ADOLF R. MARKO, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

In-house research and development work on pulse modulated personal telemetry systems resulted in the design of a seven channel pulse duration modulated transmitting unit. This preliminary model is described in Technical Report, AMRL-TDR-63-96. Continued research on this system has been combined with contractual effort in order to produce miniaturized personal telemetry units with advanced performance. The design factors, as well as the results of a series of performance tests, are the subject of this paper. The units are capable of transmitting the following measurements: electroencephalographic, electro cardiographic, electrooculographic, respiration, base skin-resistance, specific galvanic response, and body or skin temperature. The transmitting range is in the order of 200 feet; continuous operating time, on one self-contained battery, is 30 hours. The transmitting unit measures 4 x 2¼ x ¾ inches and weighs 10 ounces complete with battery. The units are used to monitor human subjects under normal and experimental stress conditions. Unencumbered subjects have been monitored while performing routine laboratory and office work to obtain baseline information about the normal variance of the physiological factors. The telemetry units have also been used successfully to monitor subjects on a small centrifuge (spin table), in different programs. The problems encountered and the results obtained in these experiments will be discussed.

A Theoretical Man-Machine Interaction Which Might Lead to Loss of Aircraft Control.

J. F. MARTIN, B.Sc., and G. MELVILL JONES, M.A., M.B., Unica Research Company and DRB Aviation Medical Research Unit, McGill University, Montreal, Canada.

During flight maneuvers the direction of the *apparent* gravitational vertical continually changes, since it parallels the vectorial resultant of the linear accelerations attributable to gravity and the aircraft. As is well known, this can lead to illusory changes in attitude; for example a false impression of pitch-up change in aircraft attitude on accelerating forward in straight and level flight.

Theoretical considerations presented in this paper suggest that possibly a similar, but more extensive, illusion might arise during a push-over, or bunting, maneuver, due to "backward" rotation of the apparent gravitational vector which then ensues. If the resultant "g" is negative throughout, the vector rotates through 360° from the point of initiation of the maneuver from a steady climb to its termination in a steady straight descent. From his gravity sensing receptors a pilot would presumably interpret this as a large change of aircraft attitude in a *pitch-up*, or looping, direction, when in fact the aircraft is pitching nose-down. The natural stick-forward corrective action would worsen the maneuver, and if the resulting negative "g" became sufficiently great this could introduce adverse longitudinal stability characteristics in the aircraft due to the associated negative incidence of airflow over the wings. This in turn would tend further to increase the violence of the maneuver, possibly even to the extent of its becoming self perpetuating. Careful planned experimental studies in flight, and a detailed appraisal of high negative incidence stability characteristics in any given aircraft, are required before further evaluation can be made of the theoretical implications outlined above.

Superoxide Atmosphere Control System for Manned Space Assemblies.

J. W. MAUSTELLER, M. J. MCGOFF, D. A. KEATING and K. WEISWURM, MSA Research Corporation, Callery, Pennsylvania, and Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Extensive research and manned experimentation has been performed with alkali metal superoxides during the past years. Not as much effort, however, has been expended to the development of prototype superoxide systems for atmosphere control of manned space assemblies.

The purpose of this paper is to present the findings of a research and development effort sponsored by the U. S. Air Force to yield a reliable prototype potassium superoxide atmosphere control system for one astronaut for one day. The system combines both passive and active atmosphere control techniques to minimize weight, volume, and power requirements. The superoxide system supplies metabolic oxygen at balanced rates while removing exhaled carbon dioxide and most of the water vapor from manned sealed enclosures. Total weight of the system for one man is less than twelve pounds which is less than the weight of life support systems currently available for manned space operations of the same duration.

Results of manned sealed environmental experimentation indicating the feasibility and effectiveness of the superoxide systems are presented. The experimentation was performed in a one-man capsule of the same volume as emergency or extravehicular hard shell configurations.

Superoxide systems have finally found their place in manned aerospace operations as evidenced by the results of this effort. The superoxides are no longer items for cross-over chart predictions or speculations, but they can now be considered as off-the-shelf flight hardware systems for atmosphere control of manned space assemblies.

Further Studies of the Mechanism of *in vivo* RBC Damage by Oxygen.

C. E. MENGEL, M.D., L. G. ZIRKLE, B. W. O'MALLEY, M.D., and B. D. HORTON, Department of Medicine, Duke University, Durham, North Carolina.

In previous work we showed that RBC damage and hemolysis in animals and humans during exposure to oxygen under high pressure (OHP) was directly or indirectly caused by peroxidation of RBC lipid. In the present study RBCs from 20 dogs were studied before and after in vivo OHP (100 per cent O_2 at 5 Atm. for 1-3 hours) for 1) routine hematologic indices, Price-Jones curves; 2) glucose-6-PO^4-dehydrogenase and catalase activity, reduced glutathione and methemoglobin content, and Heinz bodies; 3) acetylcholinesterase (AChE) activity; 4) lipid peroxides; 5) osmotic fragility. No evidences of hemolysis were noted, and all studies were normal except as follows. After OHP, RBCs from all dogs showed: 1) initiation of in vivo lipid peroxide formation; 2) significantly decreased AChE activity; 3) significantly increased osmotic fragility (evidence of latered RBC membrane permeability). Subsequent in vitro studies showed that oxygen per se did not inhibit RBC AChE. However, erythrocyte AChE activity was inhibited by slow steady state exposure to diffused hydrogen peroxide (similar to conditions that might occur in vivo during hyperoxia) and by lipid peroxides (previously shown to be formed in vivo during OHP). These data are consistent with the hypothesis that the in vivo decrease of RBC AChE activity noted in the dogs during OHP resulted from enzyme inhibition by the formation of lipid peroxides in vivo. Since in vitro studies have shown that inhibition of AChE activity altered membrane permeability and increased osmotic fragility it is possible that this effect is a mechanism of red cell damage and hemolysis during in vivo hyperoxia.

The Effect of Anthocyan Glucosides on the Night Vision Capabilities of Aircrew.

A. MERCIER, M.D., E. LAFONTAINE, M.D., J. ROBION, M.D., and G. PERDRIEL, M.D., Service Medical d'Air France, Paris, France.

A series of tests has been performed with a view to assessing the possibilities of improving night vision capabilities on the ground and in flight.

As shown previously, anthocyan glucosides bring down the adaptometric thresholds, which corresponds to an improvement of night vision.

The objective of the tests carried out was to check the long range and short range effect of this product. They consisted in determining not only the value of adaptometric thresholds, but also the behavior of the scotopic components of the electroretinogram.

The investigation dealt also with the functional and objective results noted on flying personnel performing various air

missions: long range flights averaging six hours of night flight, and repeated medium range flights (over a fifteen-day period of continuous activity).

The first observations which were recorded indicated that the absorption of this product resulted in an improvement of aircrew behavior during in-flight activities at low lighting.

Reversal of Decaborane—Mediated Norepinephrine Depletion by Mehtylene Blue.

JAMES H. MERRITT, B.S., and CAPT. JOHN A. MERRITT, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Decaborane ($B_{10}H_{14}$) has been shown to deplete norepinephrine stores from rat brain (Merritt, J. H., et al., Biochem. Pharmacol., 1964). Merritt has shown that continuous infusion of methylene blue increased survival times of rabbits intoxicated with decaborane (Merritt, J. A. Arch. Intern. Med (Chicago), 1964). Previously, Ehringer, et al. (Arch. Exper. Path. u. Pharmakol., 1961) demonstrated that administration of methylene blue increased the catecholamine and serotonin content of rat brain. In order to determine if methylene blue would prevent depletion of norepinephrine induced by decaborane from rabbit brain stem and heart, the animals were injected intraperitoneally with 15 mg. of decaborane/kg. The rabbits then received 7 mg. methylene blue/kg. over a 1-hour period, and then 0.13 mg./kg. per hour (in 5 per cent glucose) as a continuous drip over a 6-hour period. Control animals received 5 per cent glucose over a 6-hour period. Decaborane alone caused a fall to 35 per cent and 57 per cent of control norepinephrine concentrations for brain and heart respectively. Methylene blue alone increased the norepinephrine concentration of brain 235 per cent and of heart 146 per cent. A combination of methylene blue and decaborane increased brain norepinephrine to 145 per cent and decreased the heart norepinephrine to 83 per cent of the control values. Neurochemical significance of the findings will be discussed.

Treatment with methylene blue of individuals intoxicated with boron hydride seems more rational than the present symptomatic therapy.

Free Fatty Acid Response to Tilting Following Immersion.

MICHAEL MCCALLY, M.D., and CAPT. JACK GOLDMAN, USAF, MC, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Orthostatic intolerance is seen in human subjects following prolonged bed rest and water immersion. Serum free fatty acids are released by noradrenaline and rise rapidly during the normal response to passive vertical tilt. Blood pressure, heart rate, plasma glucose and free fatty acid responses to a six degree vertical tilt for thirty minutes were studied in six subjects following six hours of complete water immersion, six hours of heat exposure simulating the thermal characteristics of the immersion and six hours of office activity control. Heart rate response to tilt was least after heat, greatest after immersion and significantly different in both cases from that following office control ($P < 0.01$ paired samples). During tilt after heat and office control, free fatty acids rose normally. After immersion the free fatty acids fell 20 per cent ($p < 0.01$) and then rose slowly toward control levels. Plasma glucose levels did not change significantly in response to any of the tilts. The impaired fatty acid response to tilt after immersion supports the hypothesis that the known diminished urinary excretion of noradrenaline during water immersion reflects decreased sympathetic vasomotor activity in turn contributes to the orthostatic intolerance. The possible relationships of disuse and inactivity to the metabolism of noradrenaline are discussed.

Human Performance Under Prolonged Work Stress.

WILLIAM A. MCLAURIN and CLAYTON R. COLER, NASA Ames Research Center, Moffett Field, California.

A battery of performance tests, consisting of running short-term memory, simple and choice reaction time, arithmetic computation and two-handed steadiness, was administered to male subjects at 90-minute intervals during a 24-hour period of rest or continuous treadmill walking. After performance test training, each subject participated in both the resting and working conditions on separate days. The tests were administered to the working subjects while they were walking at approximately 2.75 miles per hour (not all subjects were able to complete the 24-hour work schedule). Decrements in performance occurred in both the resting and working groups in short-term memory, simple reaction, and choice reaction time over test sessions. Arithmetic computation showed no decrement over time under either the working or resting state. After an initial period of improvement, performance by the working group on the two-handed steadiness test showed significant decrement.

It was concluded that work-stress, under the condition of this study, did not produce a greater decrement in performance on tests which had a high component of intellectual functioning than did a corresponding period of rest.

Comparative Studies on 1285 and 2800 Megacycles/Sec., Pulsed Microwaves.

SOL. M. MICHAELSON, D.V.M., R. A. E. THOMSON and JOE W. HOWLAND, University of Rochester School of Medicine and Dentistry, Rochester, N. Y., and Griffiss AFB, Rome, N. Y.

As part of the U. S. Air Force Radar Hazards Evaluation Program, studies are underway to determine and express quantitatively the biological and biomedical effects of acute and chronic exposure to microwaves at different frequencies, power densities, wave-form characteristics and relevant environmental conditions. Comparative studies of exposure of dogs to 1280 Mcycles/sec and 2800 Mcycles/sec pulsed microwaves reveal subtle differences and similarities which provide the basis for a model of response to a wide variety of radar energies. Dogs exposed at a flux density of 100 mw/cm^2 1280 Mcycles/sec pulsed microwaves for six hours do not appear as agitated as dogs exposed to 2800 Mcycles/sec. Panting during exposure at the lower frequency is not as marked or labored as that which occurs with the higher frequency. One day to twelve months following six hours of exposure at 100 mw/cm^2, 1280 Mcycles/sec microwaves a mild to moderate neutropenia and lymphocytosis is evident. Hematologic changes after exposure at 20 mw/cm^2, 1280 Mcycles/sec microwaves six hours daily, five consecutive days a week for two weeks, do not differ significantly from the hematologic response in sham exposed dogs, although, trends towards lymphocytosis, decreased hematocrit and reticulocytosis are noted in the microwave treated animals. There is a direct relationship between body weight loss and microwave field intensity at both frequencies. Since perception of 1280 Mcycles/sec microwaves seems less apparent than 2800 Mcycles/sec, any microwave associated hazard may be of greater concern at the lower frequency.

Otolith Activity as a Function of Gravitational Acceleration from Zero to One G.

EARL F. MILLER II, Ph.D., CAPT. ASHTON GRAYBIEL, MC, USN, and ROBERT S. KELLOGG, Ph.D., Naval School of Aviation Medicine, Pensacola, Florida, and Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Previous experiments revealed that ocular counterrolling is a specific indicator of otolith activity under hypogravic as well as normal gravitational stimulation. A photographic technique allowed precise measurement of even relatively small amounts of rolling that occur particularly under subgravity conditions or in individuals with defective labyrinths. During transient periods of weightlessness, the otolith organs appeared to be physiologically deafferented while during similar periods of 0.5G their activity was reduced below one-half that found at 1.0G. These data indicated a nonlinear relationship between otolith activity and G force which was explored further in the present study. Ocular counterrolling response in three positions of tilt under several subgravity conditions was determined in four normal subjects. The tilt and recording apparatus used were mounted in a KC 135 aircraft that was specially equipped to fly precise Keplerian trajectories. The data obtained confirmed that otolith activity is a nonlinear function of inertial force at least between zero and standard G. This function and its possible significance in space travel are discussed.

The Effect of Lower Body Negative Pressure During Prolonged Bed Rest on Circulatory Functions in Man.

MAJ. P. B. MILLER, USAF, MC, P. M. STEVENS, M.D., LT. COL. R. L. JOHNSON, USAF, MC, and L. E. LAMB, M.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The application of negative pressure to the lower half of the body of supine subjects has been shown to diminish cardiac output, elevate the heart rate, and decrease the systolic blood pressure. Since the physiologic effects on the cardiovascular system are similar to head-up tilting, lower body negative pressure might be used during prolonged space flight both as a countermeasure to prevent the development of postural intolerance and as a testing procedure to evaluate changes in postural tolerance.

Six healthy subjects underwent four weeks of absolute bed rest. Lower body negative pressure alternating between –50 mm. Hg for 4 minutes and –25 mm. Hg for 2 minutes was applied to each subject for 4 hours daily. Tolerance to negative pressure of –60 mm. Hg for 20 minutes was determined weekly during bed rest. Changes after bed rest in blood volume and tolerance to sustained lower body negative pressure, 90 degrees head-up tilting, and treadmill exercise will be presented.

In-Flight Response to a New Non-Gyroscopic Antivertigo Blind Flight Instrument.

STANLEY R. MOHLER, M.D., and A. HOWARD HASBROOK, Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

Human responses to a new "geomagnetic" non-gyroscopic blind flight instrument have been recorded during flight utilizing an aircraft typical of those flown by general aviation pilots.

Recordings were made under induced conditions of loss of control during simulated instrument flight.

Subjects used in the program ranged from student pilots with 60 flight hours minimum experience to commercial pilots with up to 10,000 hours experience.

The device, known as the Kenyon instrument, is self-contained, weighs 7.2 ounces, requires no vacuum source, no electrical power, and no connection with any moving part of the aircraft. It is non-tumbling and not susceptible to turbulance oscillation.

The series of tests included comparisons under similar conditions of pilot responses to a conventional blind flight instrument display with their responses to the new type display.

Results demonstrate a more positive and smooth control of the aircraft with the new instrument as objectively measured by photographic recordings of the flight instruments. Also, subjective measures indicate a decreased tendency to the onset of vertigo with the new instrument.

It is concluded that the instrument would be of material benefit in reducing the annual toll of fatal light plane accidents which result from loss of control by non-instrument trained pilots who lose visual reference to the natural horizon. It will also be of value to instrument trained pilots whose conventional flight instruments fail under IFR circumstances.

Effects of Low Frequency and Infrasonic Noise on Man.

CAPT. G. C. MOHR, USAF, MC, J. N. COLE, LT. COL. E. GUILD, USAF, and H. E. VON GIERKE, Dr., Ing., Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Future manned space systems, with larger payloads and more powerful boosters, will generate during launch operations a noise environment with maximum sound pressure levels in the 1-100 cps frequency range. Such noise environments—particularly with noise levels above 110 to 120 dB re 0.0002 microbar in the frequency range 1-20 cps—are without precedence and no experience as to their biological effects exists. In order to obtain a preliminary evaluation of human tolerance to such noise fields, five noise-experienced human subjects were exposed for periods of at least two minutes to high intensity broad band, narrow band, and pure tone low frequency noise. The facility used for the extreme infrasound exposures was the new Low Frequency Noise Facility at the NASA Langley Research Center. The effects of these exposures on cardiac rhythm, hearing threshold, visual acuity, fine motor control, spatial orientation, speech intelligibility, and subjective tolerance were observed. Exposures up to 150 dB re .0002 microbar overall sound pressure level were achieved, thereby extending the range of known human exposure to noise in this frequency range substantially (20 to 40 dB) above prior laboratory or operational experience. The observed objective and subjective responses of the subjects demonstrated that with ear protection short duration exposures to low frequency noise at these sound pressure levels are within human tolerance limits. Speech communication might pose a problem, depending on spectral composition, equipment used, and the protection provided.

This program was conducted in part under NASA Defense Purchase Request T-22031G.

Fear of Flying and the Counterphobic Personality.

CAPT. ALAN L. MORGENSTERN, USAF, MC, USAF School of Aerospace, Brooks AFB, Texas.

The development of a neurotic fear of flying in aerial crewmembers is neither rare nor easily treated. Basically phobic attitudes often masquerade as the common apprehension of training until anxiety becomes so severe grounding is mandatory. The human and material costs are enormous.

A history of severe childhood fears of such things as darkness, injury, and especially of heights, is a warning that a phobia may develop in adult life. Case studies show that phobic children may try to master their fears by repetitively exposing themselves to the specific situation evoking anxiety. In adult years they are attracted to dangerous sports and occupations with the psychological aim of denying their fear. This unconscious defense mechanism is a "counter-phobia" and when prominent leads to the diagnosis of "counter-phobic personality." In the hope of proving their fearlessness, aviation may be chosen as a hobby or a career. This symptomatic need to fly leads to poor flying judgment, increasingly hazardous flying, or eventually breaks down into a phobia of flying.

When an applicant's history suggests severe childhood probias or persistent participation in dangerous work or recreation, a psychiatric consultation is needed. If the consultant confirms the existence of repetitive and compulsory counter-phobic traits, the applicant should be disqualified for flying training.

Hyperventilation Apnea.

KENNETH M. MOSER, M.D., P. GREGG RHODES, M.D., and L. KWAAN, M.D., Georgetown Clinical Research Institute, FAA, and Georgetown University Hospital, Washington, D. C.

We have previously reported a group of patients with sedative overdosage in whom hyperventilation with mechanical respirators induced apnea. This apnea was related to hyperoxic, hypocapnic alkalosis. The current study was undertaken to determine the response of normal subjects to hyperoxic, hypocapnic alkalosis.

Thirteen normal subjects were studied before, during and after hyperventilation in room air and 100% oxygen, prior to and following administration of 100 mgm Nembutal IM. Expired CO_2 concentration and respiratory rate were continuously monitored. Arterial P_{CO_2}, pH and PO_2 were measured before, during and after each hyperventilation period.

Comparable degrees of hypocapnic alkalosis ($P_{CO_2} < 25$ mm. Hg; $pH > 7.60$) were induced after each hyperventilation period. Following hyperventilation, two types of response were noted; no change in respiratory pattern; or irregular respiration punctuated with one or more apneic periods (> 5 sec.). *Before Nembutal,* room air hyperventilation led to apneic periods in 5 subjects (5-17 sec.) while oxygen hyperventilation produced apnea in 8 (8-18 sec.). *After Nembutal,* room air hyperventilation was followed by apneic periods in 10 subjects (6-40 sec.) while oxygen hyperventilation led to apnea in 11 (5-60 sec.). It is concluded that apnea can be induced in normal subjects by hyperventilation alkalosis, and the incidence of apnea is increased by concomitant hyperoxia and barbiturate administration.

Bacteriologic Potability of Condensate Water from Heat Exchangers of Pressure Suits.

CAPT. J. E. MOYER, USAF, MSC, and C. H. WARD, Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

For space missions of lengthy duration, or for missions where man will be required to perform tasks at a distance from the space cabin, the resupply of potable water poses a problem. The possibility of utilizing water condensates recovered directly from the heat exchangers of pressure suits as an emergency source of drinking water was investigated. Five-hour condensate samples were collected and subjected to quantitative and qualitative bacteriologic analysis. Results indicate that condensate water may serve as an emergency source of potable water provided it is consumed within a short period of time following collection. Storage of the condensates results in a water of an unacceptable bacteriologic purity for inhibition purposes.

Effects of Brief Thermal Transient to 205°C (400°F) on the Clotting Mechanism in Human Subjects.

R. H. MURRAY, M.D., Indiana University Cardiopulmonary Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

In order to simulate the potential thermal stress to which astronauts may be exposed during re-entry in the event of air-conditioning failure, each of seven Air Force volunteers was seated (clothed) in a small aluminum chamber the walls of which were heated at the rate of 10°C (50°F) per minute to a peak temperature of 205°C (400°F). The chamber cooled passively for the succeeding fourteen minutes. The rectal temperature rose 0.5°C and mean weighted skin temperature rose to 42°C. Because of significant delayed bleeding in two subjects following earlier experiments, the clotting mechanism was evaluated before and after the heat stress.

There was no significant change in tourniquet test, bleeding time, prothrombin time, or prothrombin consumption time. Serum protein electrophoresis was essentially unchanged. Platelet counts and fibrinogen levels rose slightly. Venous clotting time varied widely but was very significantly prolonged in three subjects. Fibrinolytic (plasmin) activity was uniformly and significantly increased, four of the seven subjects exhibiting 80-100% lysis in five hours in post-heat samples.

There is both clinical and laboratory evidence of significant and potentially dangerous accentuation of fibrinolysin activity following thermal stress of this type.

Effects of Repeated, Low-Intensity, Long Duration, Positive Accelerations (+G_z) in Dogs.

R. H. MURRAY, M.D., MAJ. JAMES PRINE, USAF, VC, and RICHARD P. MENNINGER, Indiana University Cardiopulmonary Laboratory and Toxicology Branch, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Because of recent proposals to provide intermittent centrifugation for astronauts during prolonged spce missions, it seems important to study the effects of repeated, low-intensity, positive accelerations, especially so since severe renal lesions in dogs following this type of stress have been reported by Senelar.

Each of six healthy mongrel dogs was anesthetized and exposed to one hour of positive acceleration (+G_z) at an intensity of 2.5 G twice weekly for fifteen weeks or until death. Two additional dogs were anesthetized in an identical manner, but were not exposed to centrifugation.

Four of the test dogs died during the course of the experiment, each during centrifugation (during the second, seventh, tenth and twentieth hour). Two dogs completed the program. None of the deaths was anticipated; each dog appeared normal before and after each period of stress unless and until found dead.

Post-mortem examinations in those dogs completing the test program and those only stressed by anesthesia were essentially normal. Examinations of those dying during centrifugation demonstrated only mild-to-moderate congestion of the caudal portions of the lungs and viscera. There were no renal lesions of the type described by Senelar.

The high mortality and unexplained cause of the deaths in this study show clearly the importance of further, more detailed investigations of this type of stress.

Between Two Generations.

HAROLD A. MYERS, M.D., Eighth Air Force, Westover AFB, Massachusetts.

This is a historical presentation and not a scientific treatise, and a literary attempt at bridging the gap between the older generation of active flight surgeons who have been in the business for more than a quarter century, and the new generation. An effort to bring ourselves across the years from 1938 to 1965; and to project ahead a quarter century to the year of 1990. What we anticipate in those years that lie as far ahead of us now, as the year 1938 lies as far behind us.

This paper is not at all a personal reminiscence. A brief look back at the years preceding World War II, insofar as Aviation Medicine is concerned. A few words about the B-29 program, the Atomic Weapon, then a look at present-day aircraft and weapons systems. A brief description of a Chrome Dome mission, then a glance into the near future and into the year 1990, just before the turn of the next century.

The Effect of Hypoxia on Nystagmus Induced by Angular Acceleration.

S/L P. D. NEWBERRY, RCAF, S/L W. H. JOHNSON, RCAF, and S/L J. R. SMILEY, RCAF, RCAF Institute of Aviation Medicine, Toronto, Canada.

Four subjects were exposed to horizontal angular acceleration of approximately 156° $sec.^{-2}$ for 1 second, while breathing air at ground level followed by breathing air at 20,000 feet and then while breathing 100 per cent oxygen at ground level followed by breathing air at ground level.

Total slow phase angular deviation of the eye, maximum slow phase angular velocity and total duration of nystagmus were used to measure the magnitude of nystagmus.

There was a mean increase of 61 per cent in the slow phase angular velocity of the nystagmus occurring while breathing 10 per cent oxygen compared with breathing air at ground level. At 20,000 feet, however, there was a mean increase of almost 100 per cent in total angular deviation, maximum angular velocity and total duration of nystagmus compared to breathing either 10 per cent O_2 or air at ground level. This is attributed to the obvious anxiety displayed by the subjects at 20,000 feet.

It is suggested that hypoxic hypoxia and the associated hyperventilation increase the nystagmus resulting from a horizontal angular acceleration and that apprehension may cause a much greater increase in nystagmus.

Adaptation to Prolonged Exposures in the Revolving Space Station Simulator.

B. D. NEWSOM, Ph.D., J. F. BRADY, A.B., W. A. SHAFER, M.D., R. S. FRENCH, Ph.D., and J. L. PIATT, A.B., Aerospace Medicine, General Dynamics/Astronautics, San Diego, California.

Subjects were exposed continuously to 6 RPM for five days at a twenty-foot radius, and were maintained on a work-rest cycle of three hours on duty—five hours off duty. In space this situation would produce a one-third g environment. The experiment was performed to establish baseline information on adaptation rate in physiological, psychological and biochemical systems. The test was run at a rotation rate that produced considerable vestibular stimulation but only a small increase in resultant inertial force (approximately 1.05 g). Portions of the test results will be presented that:

1) demonstrate the pattern for edjustment to this unique environment and 2) describe the rate at which readjustment to a static environment takes place following rotation. Data indicate that this is a severe stress but one to which sufficient compensation is possible to permit satisfactory completion of the many tasks evolved in housekeeping and mission performance.

*NIXON (See Page 170)

*NOLD (See Page 170)

Consequence of Acceleration Gradient for Tolerance to Positive Acceleration ($+G_Z$).

J. W. NYBERG, M.D., R. H. GRIMES, and W. J. WHITE, Ph.D., Missile and Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, California.

A major consideration in the design of a human centrifuge is the trade-off of radius of rotation and angular velocity. The former determines the acceleration gradient across the man, while the latter defines the coriolis acceleration associated with bodily movement. In order to explore the consequence of acceleration gradient for man the Douglas Aircraft Company variable radius centrifuge was used in conjunction with bioassay and cardiovascular criteria. Six subjects were exposed to positive acceleration where the gradient ranged from 30 per cent at a 172 inch radius to 250 per cent at a 30 inch radius. Radius is defined as the distance from the center of rotation to the heart. The data show that the average g-level at blackout increased as the radius decreased. At the shortest radius, discomfort in the lower legs limited the maximum level of acceleration. Heart rate also showed progressive changes with decreasing rate.

Alcohol Effects at Ground and Altitude: Immediate and Delayed Effects Upon a Serial Self Paced Coordination and Logic Task.

WILLIAM F. O'CONNOR, Ph.D., and ROBERT ROSENSTEIN, Ph.D., Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

A series of two experiments on the immediate and delayed effects of alcohol upon performance on a composite coordination and logic test were carried out at two chamber altitudes, 2,500 feet and 12,000 feet. The performance task requires the use of all four limbs to effect a response, as well as requiring the subject to logically decode a simple signal system to ascertain the correct response. The task was self paced, and the subjects were motivated by a bonus system of monetary rewards. Subjects estimated their task times and also completed a brief questionnaire evaluating the felt effects of alcohol over the ten hour run. Peak blood alcohol averaged 85 mg per cent.

Performance decrement immediately following the administration of alcohol followed the usual results found in the literature. The performance rate reached a maximum decrement of 30 per cent. Approximately five hours after alcoholic ingestion performance returned to normal. For runs at 2,500 feet a secondary performance rate decrement (9 per cent) occurred at seven and eight hours after alcohol ingestion, corresponding to the period of time when phase II effects are observed in positional nystagmus. The secondary performance decrement did not appear as strong at 12,000 feet.

Some Observations on Dogs Following Lower Body Exposure to 1 MEV X-Rays.

LT. COL. LAURENCE T. ODLUND, USAF, MC, and SOL M. MICHAELSON, D.V.M., Air Force Logistics Command, Wright-Patterson AFB, Ohio, and University of Rochester School of Medicine and Dentistry, Rochester, N. Y.

In an effort to define some of the consequences of partial-body exposure to ionizing radiation, and as a means of better understanding biological response to this injury, thirty pure bred beagles were given lower body (ziphoid process caudad) exposures to 1 MEV X-rays. An additional ten animals served as controls.

Mortality was 12 per cent at a single dose of 875r (mid-line air), 100 per cent at doses of 950 and 1100r. Deaths occurred at 3-4 days post-exposure. When the total dose was 950r given in four equal increments at 24-hour intervals there was no mortality.

In survivors weight loss was significant at all doses but much greater when the total exceeded 800 r. Rectal temperatures did not rise appreciably above control values during the 60-day observation period. Lymphocytes and neutrophiles displayed characteristic drops at all dose levels and little or no recovery of the former cell type was observed. Erythrocyte sedimentation rates did not rise, and the hemoglobin and hematocrit values in survivors did not fall significantly below control values.

On the basis of this and subsequent studies the 60-day median lethal dose for lower-body exposure in the dog is estimated to be about 900-950r (mid-line air). Provided the gut withstands the radiation insult, the shielded portion of the body has sufficient reserve to provide normal numbers of erythrocytes. In situations where weight limits amount of shielding available for protection of personnel, provisions for protection of head and torso would increase by many times the dose required for serious acute effects of radiation illness.

A Simple Method for Determining Body Specific Gravity.

LCDR. M. PASSAGLIA, MSC, USN, CDR. E. REEVES, MSC, USN, and CAPT. E. L. BECKMAN, MC, USN, Naval Medical Research Institute, Bethesda, Maryland.

A method is proposed for the determination of body specific gravity in which the air-free body weight in water is estimated by means of the difference in underwater weight produced by a rapid change in pressure from 1.0 to 0.5 atm. which was accomplished by use of a low pressure chamber.

This method corrects for the gastro-intestinal gas volume and eliminates the need for measuring the residual volume of the lungs as required by the usual method for calculation of body specific gravity by the Archimedean principle.

Task Interruption and Performance Decrement Following Rapid Decompression.

CAPT. GEORGE E. PENDERGRASS, USAF, and WILLIAM F. O'CONNOR, Ph.D., Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

Seventeen subjects, all aircrewmen or pilots, were decompressed through a pressure differential of 8.66 p.s.i. to altitudes from 25,000 to 41,000 feet. Time involved followed the Harber-Clayman curve, and the subjects had no warning as to when decompression would occur. The subject's task was to operate a multiple response serial coordinator. Following at 14,000 ft. pressure signal, they were to don a quick donning mask (the Puritan sweep-on), and then to immediately resume the coordinator task. All subjects received coordinator training to establish a baseline prior to decompression, and also practiced mask donning. Strip chart recordings provided measures of task interruption due to mask donning and measures of performance decrement following decompression. Film records permitted finer analysis of responses. Results: Performance decrement over the three to four minute period following decompression appeared linearly related to decompression altitude. At 35,000 and 41,000 feet performance rate slowed down some 40 per cent. Differences were observed on physiologically and non-physiologically trained subjects. Average task interruption time, which encompasses reaction time, mask donning, and task resumption, was found to be 15.4 seconds, and was independent of decompression altitude. Average hands off controls time was 10.4 seconds, and projection of this data by combinatorial analysis for a two-man crew indicate that 14 seconds would elapse before both pair of hands would return to the controls.

Human Tolerance to G_Z 100% Gradient Spin.

CAPT. T. E. PIEMME, USAF, MC, A. S. HYDE, M.D., M. MCCALLY, M.D., and CAPT. G. POTOR, USAF, MC, Aerospace Medical Research Medical Laboratories, Wright-Patterson AFB, Ohio.

The concept of short radius on-board centrifugation has been suggested, should simulated gravity be found necessary during prolonged space flight. That this is not equivalent to a distributed gravity field is obvious. As a first step to any further consideration of such a device, as a countermeasure to any deconditioning effects of space flight, further understanding of the tolerance and physiologic effects of high G gradient systems is necessary.

Eight Air Force volunteers have been studied on a short radius (five feet) spin table with the subject restrained in the supine position, the Z axis along the radius. Gero G_z was effec-

tively achieved at eye level; maximum G at the feet. At two arbitrarily selected rates of onset (0.1 G/sec and 0.05 G/sec) the tolerance to levels up to 8 G maximum at the feet has been determined. The electrocardiogram, blood pressure, respiration, and extraocular motion have been monitored. Tolerance endpoints were defined as peripheral light loss, cardiac rates in excess of 150/min, or pulse pressures less than 20 mm Hg. A logarithmic time-duration curve may be constructed from 8 G (at the feet), tolerable for less than two minutes, through 1 G, tolerable in excess of 4 hours. At high G levels, peripheral light loss and tachycardia were found to be limiting; in the mid-zone range musculoskeletal discomfort of the back and lower extremities were found to be limiting.

At the lower G longer term runs free water clearance and free fatty acids have been measured before and after spin. The implications of antidiuresis for the maintenance of blood volume in positive gravity and gravity free states will be discussed.

Voluntary Withdrawal from Primary Flight Training as a Function of the Individual Flight Instructor.

ENS. RICHARD S. POMAROLLI, MSC, USNR, and ROSALIE AMBLER, M.S., Naval School of Aviation Medicine, Pensacola, Florida.

Military flying by its very nature is hazardous duty. Perhaps more than any other occupation, it demands a complete dedication on the part of its personnel. Because this is true, all training commands permit flight students to voluntarily resign from the program if they so desire. However, since voluntary withdrawal *(DOR)* carries with it a sizeable money and manpower loss, it is desirable to minimize its occurrence. One of the more obvious possible causes of DORing might be that some instructors possess personality traits that tend to discourage students. With this in mind, the present study seeks to determine if some flight instructors appeared to be involved in significantly higher DOR rates among their students than did other instructors.

DOR data, as related to individual flight instructors in Naval primary flight training over a two-year period, were collected and analyzed statistically. A chi-square test was used to determine whether or not the DORs occurring in this period were distributed among flight instructors as we would theoretically expect them to be by chance.

Results indicate that no instructor or any identifiable group of instructors experienced more than a normal share of the DORs. This is not evidence, however, that there is no importance to the student-instructor relationship.

It is evidence that indices other than number of DORs must be used to explore this relationship.

Human Tolerance of Random and Sinusoidal Accelerative Stress.

FRED PRADKO, U. S. Army Tank-Automotive Center, Warren, Michigan.

This research paper describes a project concerned with the development of a measurement technique to identify and relate human response to random and sinusoidal vibration. A unit of measure for this purpose does not exist at the present time in any acceptable form. It is customary to speak of specific vibrations as being severe, intolerable or unpleasant. To different people, this may mean the same or a different reaction of the senses.

The program hypothesis is oriented to search for common factors in a variety of measurements which would indicate or be of value in evaluating the effects of linear and angular vibration on human beings. The starting premise was that measurable changes in human equilibrium are caused by input vibration, and that such changes may appear in: physical performance capability, ability to concentrate, ability to communicate, or biologic changes. The elements studied were:

1. Sinusoidal motion
2. Random motion
3. Single transients
4. Multiple transients

Data for human tolerance will be presented for seated and standing conditions under *random* and *sinusoidal* conditions:

MODE	*DISCRETE OR CENTER FREQUENCY*
a. Vertical	1 - 50 CPS
b. Pitch oscillation	1 - 50 CPS
c. Roll oscillation	1 - 50 CPS
d Vertical and pitch	
e. Pitch and roll	
f. Vertical, pitch, and roll	

Graphs of tolerance characteristics will describe the effect of human response for different vibration input paths considering the feet, head, and through the seat back rest cushion.

Data will describe whole body changes in terms of acceleration, frequency, and displacement. Information will also be presented comparing input signals to the local vibratory response of the human body.

For oral presentation, the test and experimental procedures will be described in detail through the use of a 15-minute 16mm motion picture film.

Effect of Exercise on Oxygen Consumption at Decreased Pressure.

CAPT. D. G. QUIGLEY, USAF, MC, CAPT. W. G. ROBERTSON, USAF, MSC, and G. L. MCRAE, USAF School of Aerospace Medicine, Brooks AFB, Texas.

To determine logistical requirements for oxygen for space flight necessitates a knowledge of man's oxygen consumption under all conditions. Seven healthy young men were exercised on a treadmill at 3.4 mph, 0° incline; and at 3.4 mph, 10° incline at sea level (approximately 747 mm. Hg) and 27,000 feet (258 mm. Hg). Oxygen consumption, carbon dioxide output, and heart rate were measured. Studies were made with air, 30 per cent oxygen in nitrogen, pure oxygen at ground level, and pure oxygen at altitude. The 31 per cent oxygen-69 per cent nitrogen mixture at ground level and pure oxygen at altitude yielded the same alveolar oxygen tension (171 mm. Hg). This allowed the study of the effect of a pressure change at the same alveolar oxygen tension. Oxygen consumption and heart rate were found to be constant after 3 minutes of exercise. Oxygen consumption values are reported for the average of 2 minutes for the fourth to sixth minute of exercise. No significant differences were noted in oxygen consumption, carbon dioxide output, or heart rate within any work load with gas mixtures or altitude. It is concluded that altitude has no effect on oxygen consumption with work and that ground level studies can be used to determine logistic requirements at reduced pressure.

Some Physiological Observations and Monitoring Technics Associated with Auto Racing.

RITA M. RAPP, M.S., LAWRENCE F. DIETLEIN, M.D., and JOHN C. NUTTALL, Space Medicine Branch, NASA-Manned Spacecraft Center, Houston, Texas.

The heart rate response of sports car drivers participating in competitive events are presented. This study includes both short and long distance races, as well as professional and non-professional drivers. Sustained heart rates of 120 beats per minute up to 165 beats per minute, for periods of 2 hours, have been observed. The heart rate throughout a race appears to be an individual characteristic. Maximum increases were observed at the start of the race. These observations differ from heart rates reported on pilots during high performance flight, such as the X-15, and astronauts during space flight. In the latter, only short periods of elevated heart rate have been observed and these usually corresponded to critical maneuver phases. Blood samples were analyzed for 17 hydroxycorticosteroids (17-OHCS) before and after each race. The levels of plasma 17-OHCS were higher than normal diurnal curve values, however, no consistent elevations following the race event were observed. The monitoring systems used for data collection consisted of an FM-FM Telemetry system and a tape recorder system. Details of these systems are presented.

An Evaluation of the Foamed Neoprene "Divers' Wetsuit" as a Survival Garment for Helicopter Aircrew.

CDR. E. REEVES, MSC, USN, LT. M. P. STEPHENS, USN, and CAPT. E. L. BECKMAN, MC, USN, Naval Medical Research Institute, Bethesda, Maryland.

The particular type of flight performed by helicopters makes particular requirements for survival garments for their aircrew as follows: (1) Water entry by aircrew is by way of water collision so that there is a high probability of damage to the survival garment; (2) The short flight radius of the helicopter ensures that the time-distance from a potential rescuer should be relatively short, so that rescue should be expected in less than six hours; (3) The suit must be wearable without an air ventilated suit for cooling and still be usable in high cockpit temperatures up to 90° F; and, (4) the low altitude of flight allows no time to don or zipper up a survival garment so that there should be no penalty for entering the water with the garment partially unzipped.

Laboratory experiments using various types of divers' wetsuits in water established a voluntary safe tolerance time of four to six hours in 40° F and 50° F water. A voluntary tolerance time of four to six hours was established for immersion in 29° F water by the use of a foamed neoprene suit and supplemental heating to the hands and feet.

The laboratory results and resulting recommendations will be presented.

The Compulsive Flyer.

CAPT. ROGER F. REINHARDT, MC, USN, Naval School of Aviation Medicine, Pensacola, Florida.

This paper examines the significance of compulsive personality traits in the aviator. "Compulsive" implies here a tendency toward over-organization, over-conscientiousness, perfectionism, and an inability to relax. These traits have a social origin which is most influenced by parent-child interaction at ages 2 and 3. They also have a cultural origin, for Western man places a high value on time, orderliness, punctuality, and hard work. The adult compulsive personality has its normal aspects and its abnormal exaggerations (where rules come to master the ruler).

An illustrative case is presented of a very proficient but compulsive flight student who struck a psychologic snag in the Advanced Radio Instrument phase of jet training. Not being able, in his flight planning, to prepare ahead of time for every possible contingency, he became disorganized, anxious, and sick with nausea and vomiting. In brief supportive psychotherapy, the therapist acted simply to lessen the demands of the student's superego; and a year later, the patient is an above average fighter pilot.

Clinical experience has shown that compulsive people generally make fine professional aviators. They are intelligent, safe and dependable. On the other hand, instrument training is hard for them, they lack flexibility, and they often develop headaches. In new situations which are difficult to organize and clearly conceptualize, when novel problems require novel responses, they are at their worst. In workaday flying, with a premium on care, method, timing and preparation, they are at their best, and probably *the* best.

Polarographic Measurement of Blood Oxygen Tension: Sources of Error.

P. GREGG RHODES, M.D., and KENNETH M. MOSER, M.D., Georgetown Clinical Research Institute, FAA, Washington, D. C.

The wide clinical and research use of polarographic blood oxygen tension data required identification of the sources of measurement error. This report deals with two such sources: characteristics of the measuring system and pre-measurement handling of blood samples.

Study One: heparinized blood was tonometered with gases of known oxygen tension (PO_2) over a $<50->600$ mm Hg.PO_2 range. The PO_2 of the blood ($^PBO_2$) and the gas ($^PGO_2$) were then measured in a system using a miniaturized platinum electrode covered by a polyethylene or a polypropylene membrane. Study Two: aliquots of tonometered blood samples were maintained anaerobically at 0°C, 25°C or 37°C. PO_2 of each aliquot was measured at ten minute intervals for 90 minutes.

Study One: the $^PBO_2$ measured was consistently below $^PGO_2$. With the polyethylene membrane, a non-linear $^PBO_2/^PGO_2$ relationship was observed such that below 70 mm Hg. the $^PGO_2=1.20\times{}^PBO_2$; above 70 mm Hg. the $^PGO_2=1.08\times{}^PBO_2+10$. With the polypropylene membrane, a linear relationship was observed over the measured range with $^PGO_2=1.05\times{}^PBO_2$. Study Two: $^PBO_2$ did not change in samples maintained at 0°C for 90 minutes, but declined moderately in those held at 25°C and appreciably in those at 37°C.

Significant errors can be introduced in polarographic blood PO_2 measurements by the characteristics of the system used (including membrane materials) and by maintenance of samples above 0°C prior to analysis.

The Effects, Real and Relative, of a Space Type Diet on the Aerobic and Anaerobic Microflora of Human Feces.

P. E. RIELY, L. S. GALL, Ph.S., and G. A. ALBRIGHT, M.D., Space Environment and Life Science Laboratory, Republic Aviation Corporation, Farmington, Long Island, New York.

The effects, real and relative of a space type diet on the aerobic and anaerobic microflora of human feces were determined. Fecal specimens from four young men confined in the experimental activity facility at the Aerospace Medical Research Laboratories (AMRL), Wright-Patterson Air Force Base, Ohio, were cultured both aerobically and anaerobically thirteen times during a six-week period. During certain periods the men wore space suits. Two of the men were on an experimental space type diet which was freeze-dehydrated. During this same time period the other two subjects were on a "control" diet which contained identical foods, fresh and canned, in order to duplicate as nearly as possible the dehydrated diet from a nutritional viewpoint. Midway in the experiment the diets of the subjects were switched. The procedures used emphasized the anaerobic isolation of the predominating microorganisms using a specialized technique (Gall's). The aerobes were isolated and identified by standard procedures. An attempt was made to relatively quantitate the flora by the use of triplicate aerobic dilution series and by the plating from each dilution into differential media. Although the obligately anaerobic character of the flora remained constant, a shift was found in the types of anaerobic organisms isolated. This change in the biochemically distinct flora occurred after a sufficiently lengthy period on the diet to suggest that the diet was a contributing factor. The aerobic flora differed from that cited in the literature by the frequent presence of shigella and enteropathogenic types of *E. Coli.*

Respiratory Studies in a Helium-Oxygen Atmosphere.

CAPT. W. G. ROBERTSON, USAF, MSC, CAPT. H. J. ZEFT, USAF, MC, CAPT. V. S. BEHAR, USAF, MC, and B. E. WELCH, Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The pulmonary effects of a 2-week exposure to a 46 per cent oxygen-54 per cent helium atmosphere at a total pressure of 380 mm. Hg were evaluated in four healthy young men. Oxygen consumption, carbon dioxide production, alveolar ventilation, dead space, and alveolar gas tensions were determined. The various lung compartments included residual volumes were measured. In addition, vital capacities, timed vital capacities, and maximum breathing capacities were studied. Carbon monoxide diffusing capacities were measured just prior to exposure to the oxygen-helium atmosphere and immediately upon descent from altitude. All other studies were carried out during a 2-week pre-experimental control period, 2-week experimental exposure, and a 1-week postflight period.

Results will be discussed with reference to the physical characteristics of helium; and a theoretical analysis of the effects of the decreased density and kinematic viscosity of the inspired gas mixture will be presented. Respiratory gas exchange data will be related to the thermal characteristics of helium.

Feasibility Study: Lateral Impact with Minimal Restraint.

CAPT. J. D. ROTHSTEIN, USAF, MC, CAPT. W. K. BROWN, USAF, MC, Biodynamics Division, 6571st Aeromedical Research Laboratory, Holloman AFB, New Mexico.

A series of 11 impact tests using the Daisy Decelerator was accomplished by the Biodynamics Division, 6571st Aeromedical Research Laboratory, Holloman Air Force Base, to evaluate adequacy of restraint from lateral impact forces of up to 14.1 sled G using as minimal restraint standard aircraft harness and a non-contoured seat. Standard harness would offer greater range of movement to the restrained subject than would be offered by a more complex harness previously proposed and tested for Project Apollo.

Results of these 11 tests demonstrated adequacy of restraint with the standard harness at tested impact profiles. It was also observed that when the torso was not laterally supported a shallow, 2 inch (5.08 cm) deep head support was adequate at sled G less than 10 G, above 10 sled G this shallow head support was preferred to a deeper, 7 inch (17.8 cm) head support so that at impact the subject's head can rise out and over the shallow support thereby minimizing the shearing force between the head and laterally moving torso. It was also observed that amplification of G from seat to subject was about the same for both harnesses even though input force was greater in the series using standard harness. This observation suggested greater absorption of impact force by torso movement and strap stretch with standard harness than almost entire force absorption by the rigidly restrained body with more complex harness.

Pleural Pressures in Dogs During Transverse Acceleration.

W. RUTISHAUSER, M.D., N. BANCHERO, M.D.; A. G. TSAKIRIS, M.D., R. E. STURM, M.S., and E. H. WOOD, M.D., Ph.D., Mayo Clinic and Mayo Graduate School of Medicine, Rochester, Minnesota.

Six morphine-pentobarbitized dogs were exposed to forward ($+G_x$), backward ($-G_x$), right lateral ($+G_y$), left lateral ($-G_y$), and again to forward acceleration for 60-second periods at average levels of 2.1, 4.4 and 6.7 G in each position while the animals were supported in appropriate molded half-body casts. Pleural pressures at dorsal (paravertebral), ventral (retrosternal), left and right sites at the level of the heart in the cephalocaudad dimension were measured by Statham gauges and saline-filled catheters inserted percutaneously with an air-tight technique. In addition, pericardial, esophageal and circulatory pressures from aorta, right ventricle, and both atria, as well as blood oxygen saturation were continuously recorded. Corrections for the effect of acceleration on the catheter-manometer systems were determined by exposures to the same acceleration while the strain gauges were closed to the catheters and opened to a hydrostatic system with communicating fluid columns on each side of the dog with menisci adjusted to mid-lung level. Circulatory pressures were referred to this common reference point. Pleural pressures were corrected to the level of the respective catheter tips on the basis of the G level and measurements of vertical distance of each tip from the common reference level using biplane x-rays taken at expiration during each exposure. Mean pleural pressures in centimeters of water listed below were measured at end expiration at the three levels of acceleration in 3 to 5 dogs (mean anteroposterior and lateral thoracic diameters 19 and 13 cm., respectively) in which simultaneous dorsal and ventral or left and right pressures were obtained.

	$+G_x$			$-G_x$		
Dorsal Pleural	−1	+2	+11	−11	−17	−27
Ventral Pleural	−15	−25	−32	+5	+19	+37
	$+G_y$			$-G_y$		
Left Pleural	+2	+8	+29	−13	−15	−17
Right Pleural	−16	−23	−23	+4	+13	+33

The unbalanced alveolar to pleural pressure gradient and consequent dependent atelectasis and superior alveolar distention plus circulatory gradients are apparently responsible for the pulmonary pathology associated with exposure to acceleration. Supported in part by grants: NASA NsG-327, NIH H-3532 and AHA CI 10.

Effects of Vibration on the Endocrine System of Male and Female Rats.

ARTHUR W. SACKLER, M.D., and STANLEY WELTMAN, Ph.D., Research Institute of the Brooklyn College of Pharmacy, Long Island University, Brooklyn, New York.

This investigation reports the acute and prolonged effects of vibration stress on body weight growth, food metabolism, white blood cell counts and the endocrine system of albino, Wistar rats. Male and female test groups were subjected to peak acceleration forces of 2.1 g for 15 or 30 minute intervals administered daily during a 3 week period. The reciprocating shaker produced a horizontal movement having an amplitude of 4.6 cm. and a frequency of 283 cycles/min. Prior to autopsy, urinary steroid, total leukocytes, body weight, food consumption and O_2 consumption alterations were observed.

Depending upon the degree and duration of the vibratory stress as well as sex differences, significant or pronounced decreases were noted in the body weights, body weight gains, food consumption, leukocyte counts, absolute liver, kidney, spleen, thymus and seminal vesicle weights of the male rats. Corresponding significant or pronounced increases were noted in the adrenal weights and 17-OH corticosteroid and 17-ketosteroid levels. In the females, vibration stress produced less pronounced effects than in the males. However, similar changes were also observed in the leukocyte counts and absolute splenic, thymic and adrenal weights. In both sexes, the degree of change tended to diminish during the 2nd and 3rd weeks of stress. Thus, the data indicate that while vibration stimulate adrenal function and inhibits food consumption, food utilization and body growth rates of males, the females tend to be more resistant.

Cineradiographic Observations of Human Subjects During Tranverse Accelerations of +5 and +10 G_x.

HAROLD SANDLER, M.D., Naval Aeromedical Acceleration Laboratory, Johnsville, Pennsylvania.

Thirty-five mm x-ray motion pictures were recorded at 30 frames per second from a 9-inch image intensifier installed in the gondola of the Johnsville centrifuge. Five human subjects were photographed in the left lateral chest position during accelerations of +5 and +10 G_x (30 seconds duration). Anteroposterior (A-P) chest diameters decreased 8.7 per cent at +5 G_x and 15.5 per cent at +10 G_x (mean control 17.5 cm., measured as shortest distance from anterior spine to inner sternal margin). The anterior half of the diaphragm was noted to be depressed, the posterior half to become elevated. The anterodiaphragmatic sterno-costal angle became somewhat acute. The heart could not be demonstrated to significantly change position within the chest (distance of spine to most anterior aspect of cardiac shadow) when compared with A-P diameter change. Heart shadow was noted to become somewhat elongated and decrease in area during acceleration. Cineangiocardiographs of dogs before and during +5 and +10 G_x were compared with human cineradiographs at similar accelerations. A greater change in A-P chest diameter and more dorsal displacement of the heart within the chest was demonstrated for the dogs during acceleration. A 16 mm film has been prepared of cineradiography of human subjects during acceleration.

Aeromedical Factors of Titan II Support—A Summary of Two Years of Operational Experience.

CAPT. CHARLES H. SAWYER, USAF, MC, CAPT. EMORY J. SOBIESK, USAF, MC, and CAPT. BURTON JAY, USAF, MC, 803rd Medical Group, Davis-Monthan AFB, Arizona, Johns Hopkins School of Hygiene, Baltimore, Maryland, and Danville, Pennsylvania.

Aeromedical procedures employed in the support of the lead Titan II ICBM Wing (SAC) (composed of 18 missile complexes) will be summarized. Specific subjects discussed will include (1) a case report of a serious nitrogen tetroxide burn with associated chemical pneumonitis, (2) human factors in missile combat crew duty with emphasis on fatigue, noise, and nutrition, (3) propellant handlers protective equipment with special consideration to the operational use of the USAF Rocket Fuel Handlers Clothing Outfit (RFHCO), (4) disaster prevention measures with emphasis of medical training, preplacement

of medical supplies and community education, (5) results of over 2000 preplacement and periodic propellant physicals in an Air Force population will be summarized. The Titan II aerospace vehicle has been modified by NASA to provide the Gemini Launch Vehicle. These support procedures proven by operational use should be of general aerospace medical interest.

Tissue Dosages from Alpha Particles and Heavy Nuclei in Solar Particle Beams in Space.

HERMANN J. SCHAEFER, Ph.D., Naval School of Aviation Medicine, Pensacola, Florida.

Balloon and rocket observations of major flares during the past solar cycle indicate that, in addition to protons, alpha particles and heavier nuclei are regular constituents of flare produced particle beams. Though abundances relative to the proton component are usually smaller than for the ordinary cosmic ray beam, alpha particles represent, in some flare events, a substantial fraction of the total flux. Quantitative evaluation of tissue dosages in a human target behind given shield configurations shows that the alpha dose represents a sizeable addition to the proton dose only for cases of low shielding such as for an astronaut outside the vehicle protected merely by the space suit. Even then, the alpha component contributes significantly to the total rad dose only in the surface layers of a human target. The situation is different for the rem dose. Since alpha particles maintain substantially larger LET (linear energy transfer) values along substantially longer track segments than protons their fractional high LET dose is larger than that from protons down to tissue depths of more than 10 centimeters. These findings emphasize the importance of measuring separately the total and the high LET dose for a correct rem dose assessment of exposure in solar particle beams.

The Effect of Isolation in a Constant Environment on Periodicity of Physiological Functions and Performance.

K. E. SCHAEFER, M.D., B. R. CLEGG, C. R. CAREY, J. H. DOUGHERTY, JR., and B. B. WEYBREW, Ph.D., Medical Research Laboratory Department, USN Submarine Medical Center, USN Submarine Base, New London, Groton, Connecticut.

Isolation of human subjects in a constant environment results in free running of circadian cycles, as demonstrated by Aschoff in a daily shift of about 1—2 hours in two functions, body temperature and urine excretion. It has not been determined whether other functions of the organism remain synchronized within themselves during the shift from local time, in the constant environment, and whether the free running of cycles of physiological functions has effects on performance levels. For this reason, an experiment was carried out in which a larger number of physiological functions were monitored, simultaneously, in two subjects, and performance levels were measured. A climatized pressure-altitude chamber was used to provide a constant environment in which temperature was kept at 27°C ± .1°, barometric pressure at 30.560 ± .004 inches of mercury and humidity at 30 per cent ± 5 per cent. Biotelemetry systems (Biometrics) were used to record, continuously, rectal temperature, surface temperature, basal skin resistance, 2 EEGs, respiration rate, and EKG. Urine samples were collected at intervals and analyzed for electrolytes and 17-ketosteroids. Saliva samples were collected 3—4 times daily, prior to meals. Lung function tests were carried out with a Wedge spirometer 3—4 times daily, using the velocity-volume loop technique (Bartlett). Psychomotor tests were carried out twice daily and included hand-steadiness, aiming, and two-hand coordination.

During the eight-day isolation period the circadian cycles shifted 13 hours away from the local clock time, averaging 1.6 hours per day. The average total daily periodicity of both subjects was 25.7 hours. Body temperature, pulse rate and respiration rate remained synchronized during the shift. Urine excretion pattern of electrolytes and ketosteroids, as well as levels of saliva electrolytes, were also synchronized with the activity during the shift period. Data on circadian cycles of vital capacity, inspiratory and expiratory reserve, as well as maximum expiratory and inspiratory flow rate, showed a circadian periodicity which was synchronized with other physiological functions and showed the same shift during the isolation period. Performance levels, as measured with psychomotor tests, did not change during the isolation period. At the sixth and seventh day of isolation, a dissociation of the circadian cycles was noticed in urine excretion patterns and saliva electrolytes. A return to normal synchronization of body cycles with environmental time givers produced significant stress, leading to dissociation of previously synchronized body temperature, pulse rate and respiratory rate.

Correlation of Electrocardiograph and Respiration Wave Form by Area Analysis on a Digital Computer.

V. R. SCOTT, M.D., and M. E. FITZWATER, Ph.D., Western Development Laboratories, Philco Corporation, Palo Alto, California.

A waveform analysis system on the Philco S-2000 Digital Computer was developed wherein the area under the curves was computed at selected intervals. ECG and respirogram waveforms were independently analyzed by a process of A/D conversion and integration of the curve between T_1 and T_2 . . . . . T_n. The critical intervals were then computed in phase with cardiac and respiratory cycles respectively then by incremental intervals therein (i.e., P wave, P-R intervals, etc.). The computing sequence was conducted under conditions of rest, exercise, hypoventilation, and hyperventilation. The results were then autocorrelated, intracorrelated, and intercorrelated to determine diagnostic and predictive value as well as respiratory status information which would be derived from cardiac waveforms and vice versa.

Physiological Data Acquisition Without Attached Sensors.

W. A. SCHAFER, M.D., General Dynamics/Astronautics, San Diego, California.

A technique for monitoring and storage of vital physiological data without restricting sensor application has been successfully employed in human and animal experimentation. The subject is free of wires, bio packs or other applied instrumentation. To accomplish this, standard laboratory recorders have been modified and used with special sensing antennas to detect the physiological activity from a distance. Clear, well defined records are currently being recorded in a variety of conditions for two physiological parameters, pulse and respiration. Recordings have been made as a composite or signature type tracing that combines the pulse and respiration in one trace. Separate readout of the pulse rate and respiration rate has also been accomplished in digital form. In the former instance, comparison of individual records shows interesting differences between subjects. These differences are being correlated with other clinical data such as ECG, blood pressure, somatotype, ballistocardiography, etc. The future value of this technique as a clinical tool will depend on the validity of the future data with respect to other methods of bio-medical monitoring. The technique does hold promise in future aerospace experimentation particularly in small confined areas, while the subject is asleep, and under conditions where unrestricted movement must be possible.

The Relationship Between Body Lipids and Physical Conditioning.

CAPT. STANLEY R. SHANE, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

The clinical records of the consultation patients seen at the School of Aerospace Medicine during the years 1962 through 1964 are reviewed in an attempt to seek correlations between various parameters measured during their evaluation. The patients are divided into groups according to age and final diagnosis and comparisons are made between treadmill oxygen consumption as a reflection of physical conditioning and serum cholesterol, triglycerides and total lipids. In addition correlation is sought between a family history of cardiovascular disease and various blood lipids as well as the relationship to total body fat. The results are presented.

X-Radiation Effects on Vibration Tolerance of Rats.

LELAND L. SHORT, Ph.D., BERNARD D. NEWSOM, Ph.D., and JAMES F. BRADY, B.S., General Dynamics/Astronautics, San Diego, California.

Astronauts may be exposed to the effects of various space-flight factors (radiation, vibration, noise, acceleration, weightlessness, etc.), there exists a need to investigate possible synergistic effects of combinations of stress, such as radiation-plus-vibration.

One hundred and forty-one female Sprague-Dowley rats were allotted into seven experimental groups to test the hypothesis that a prior X-radiation exposure might weaken the rats and make them more susceptible to death from an acute vibration stress. The X-ray dose of 632 roentgens was administered at a low dose rate in an intermittent and prolonged manner (average of 7 r/min. for approximately 1½ hours) to produce a low borderline mortality of 5-10 per cent. The vibration stress was applied at 7, 14, and 21 days to initially irradiated groups and their non-irradiated controls.

The mortality from the vibration test did not differ significantly in the comparisons of these irradiated versus non-irradiated groups. In general, the results, although not fully conclusive, lend little support to the hypothesis that a radiation exposure of borderline lethality increases susceptibility to vibration stress.

Respiration and Heart Rate Pattern Values Computed from In-Flight Data.

LT. COL. DAVID G. SIMONS, USAF, MC, NEAL E. LOF, B.S., and PAUL CARKIN, B.A., USAF School of Aerospace Medicine, Brooks AFB, Texas.

Respiration and heart rate data were telemetered to the ground during F-100 flight and on magnetic tape during C-131 flight. Maximum, average, and minimum values, plus variance were computed from each measure for one minute epochs throughout each flight. Details of the data processing are presented separately. These measures were computed from the respiration rate and from the maxima and minima detected in heart rate waves. Low values of variance are generally observed in respiration during quiet conditions. Increased variance is frequently seen during periods associated with increased arousal. The values obtained from heart rate analyses are related to the associated changes in heart rate patterns and their physiological implications discussed. Numerical values associated with increasing degrees of flight stress are compared.

Peripheral Visual Field Loss at Altitude and Recovery Rates with Descent.

LT. W. L. SMITH, MSC, USN, and LCDR. J. J. TULLY, MSC, USN, Bureau of Medicine and Surgery, Department of the Navy, Washington, D. C.

The loss of peripheral visual field at altitude and recovery rates with descent were studied by the use of the FEREE-RAND Simplified Perimeter and a low pressure chamber.

A total of five subjects were measured at elapsed time intervals at 18,000 feet of altitude for determination of the magnitude of peripheral visual field loss. Results showed a significant loss in the order of 16-17 per cent at the end of the 20-minute elapsed time interval.

Recovery rates were found to be rapid with measuring done at 5,000 feet after descent at 5,000 fpm and at ground level pressures after a descent at 500 fpm to simulate "let-down" descent rates. Results from ground level measurements indicated an overall, terminal recovery of 14.7 per cent of the original base line visual field area.

General recommendations for future studies were made.

Human Tolerance Limits in Water Impact.

RICHARD G. SNYDER, Ph.D., Civil Aeromedical Research Institute, FAA, Oklahoma City, Oklahoma.

The wide but overlapping range presented between human levels of clinical impact trauma, as measured in the laboratory on volunteer subjects, and the extreme limits of survival which may occur in free-fall, have long presented a scientific enigma. This study has been an attempt to identify and evaluate factors critical to protection and survival in human water impact. Theoretical mathematical basis for impact loadings on the body was tested in experimental impact tests of human voluntary subjects, anthropometric, and cadaver materials. Sixty cases of free-falls survived by individuals impacting water environments at over 50 ft./sec. during the past three years were intensively investigated and analyzed. In addition, autopsy data in fatal falls occurring under similar environmental conditions during this time was compared; however, it was found that fatal cases often presented a problem as to whether death was caused by drowning, and if so, whether the impact trauma could have been survivable. The most survivable body orientation, by a factor of 5-7 times, was found to be a ($+G_z$) feet-first deceleration in which critical velocity for human survival was about 100 ft./sec. Patterns of injury and relationships of factors found to influence human survival tolerances are presented and compared with impact trauma on non-water surfaces.

The "Break-Off" Phenomenon: A Precipitant of Acute Anxiety in Jet Flying.

JOHN A. SOURS, M.D., Department of Psychiatry, Columbia-Presbyterian Medical Center, New York, New York.

The "break-off" phenomenon, a feeling of physical separation from the earth experienced by jet aviators flying alone at high altitudes and relatively unoccupied with flying details, has been well described. Several studies have suggested that the "break-off" phenomenon is related to the personality of the aviator and is most apt to occur in emotionally unstable aviators. The present report is an exploratory study which aims at an assessment of "break-off" experiences in aviators who demonstrate, on psychiatric examination, signs and symptoms of a psychiatric disorder. It is postulated that the "break-off" phenomenon can precipitate an acute anxiety attack with phobic and psychophysiological manifestations and lead to the development of a fear of flying reaction. As a corollary, it is also postulated that the phenomenon occurs most often in jet aviators with emotional and personality disorders. In addition, the "break-off" phenomenon is more apt to be reported by more experienced jet aviators who have greater contact with high altitude solitary flying.

During a 6-month interval all designated naval and marine jet aviators referred for neuropsychiatric consultation were questioned in regard to the "break-off" phenomenon. Evaluations were done at the U.S. Naval School of Aviation, Pensacola, Florida, and included open-ended psychiatric interviews, aviation research questionnaires and standard psychological batteries. In this manner 37 jet aviators were evaluated; they could be divided into two groups on the basis of significant psychopathology. It is found that there is a greater incidence of "break-off" experiences among aviators with positive psychiatric findings. The "break-off" phenomenon is shown to be a precipitant of acute anxiety attacks with phobic and psychophysiological manifestations, which leads to a fear of flying reaction. The third hypothesis is not proven; the "break-off" phenomenon is not necessarily related to greater contact with high altitude solitary flying.

Representative case histories are presented to illustrate the personality and psychodynamic factors thought to be associated with adverse reactions to the "break-off" phenomenon. The mechanisms of phobic anxiety in high altitude solitary flying are discussed. The results of low sensory input studies are reviewed in an attempt to demonstrate that anxiety reactions associated with the "break-off" phenomenon are determined by multiple factors, both intrapsychic and environmental, which warrent more intensive investigation in aviation psychiatry.

Renal Hemodynamics: The Effect of Gravity on Sodium and Water Excretion.

WILLIAM M. STAHL, M.D., University of Vermont College of Medicine, Burlington, Vermont.

Studies of subgravity experience in orbital flight or simulated weightlessness using immersion have indicated the occurrence of abnormal low solute diuresis during the subgravity exposure and postural hypotension following return to normal gravity state.

Effects of gravity and subgravity were studied in 15 water and sodium loaded dogs using the supine position; vertical head-

up position; and vertical position immersed in water to the neck. Renal tissue pressure was measured by wedged renal venous catheter technique.

Renal cortical blood flow is autoregulated over a range of hydrostatic pressures while medullary blood flow varies directly with pressure. Medullary blood flow is a factor which determines renal medullary countercurrent multiplier activity. Renal tissue pressure reflects the hydrostatic pressure applied at the afferent arteriole and glomerulus.

Change to the erect posture produced an immediate striking fall in sodium and water excretion with marked increase in urinary osmolarity. Renal tissue pressure fell to 50% of control, in spite of an increase in arterial blood pressure and inferior vena cava pressure. Immersion in water produced an immediate striking rise in water and sodium excretion with marked fall in urinary osmolarity. Renal tissue pressure rose to 250 per cent of control. Tissue pressure changes indicate that initial alterations in sodium and water excretion caused by changes in gravity result from alteration of intrarenal hemodynamics and countercurrent activity.

Studies of cadiac output under gravity and subgravity conditions suggest that renal tissue pressure changes and alterations in medullary blood flow result from changes in the level of cardiac output with relation to the blood flow demands of the entire organism. Inappropriately high cardiac output causes elevation in blood pressure or decrease in vasomotor tone, raises tissue pressure, and increases medullary blood flow with resulting sodium and water diuresis. Inappropriately low cardiac output with resulting lowered blood pressure or increased vasomotor tone, decreases tissue pressure and medullary blood flow resulting in increased tubular resorption of sodium and water. The increased sodium and water diuresis of the immersed or weightless condition therefore results from an abnormally high cardiac output caused by improvement in venous return.

Studies from this laboratory have also indicated the importance of renal tissue pressure in activating the renin-angiotensin-aldosterone system. Elevation of cardiac ouput and renal tissue pressure decreases the renin stimulus causing decreased levels of circulating angiotensin. Angiotensin has been shown to influence vasomotor responses to sympathetic stimuli. The postural hypotension noted following subgravity experience is, thus, related to similar tissue pressure changes produced by inappropriately high cardiac output.

The Effect of Age on Vetebral Breaking Strength and Stiffness.

ERNEST L. STECH, Frost Engineering Development Corporation, Englewood, Colorado.

Age results in decreased vertebral compressive strength, in terms of either endplate fracture or proportional limit definitions of strength. Data obtained by Perey in Sweden shows that the two types of strength measurements are consistent when plotted against age. Quantitative estimates of the relationship beween age and strength are provided by an analysis of the experimental strength data.

Somewhat surprising is the finding that the compressive stiffness of vertebral bodies decreases with age. This result is obtained by statistical analysis of some of Perey's data, and comparison is made between the predicted shift in natural frequency of the spinal column with advancing age and actual changes observed with live human beings on shake tables. The predictions based on cadaver data are shown to be within 2 per cent of the empirically measured frequencies of live subjects.

The combination of changes in strength and stiffness is shown to affect the predicted tolerance to impact acceleration forces, and the projected magnitude of the reduction in tolerance is presented graphically.

Effects of Intravascular Instrumentation on Orthostatic Tolerance.

PAUL M. STEVENS, M.D., and LT. COL. ROBERT L. JOHNSON, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Prolonged exposure to weightlessness, bed rest, immersion and inactivity, all have profound effects on cardiovascular regulatory reflexes, manifested mainly by the development of orthostatic intolerance. Standard tilt table testing is presently being used as the prime tool in evaluating these changes. In order to acquire more precise measurements of cardiovascular responses, intravascular instrumentation may be necessary in order to determine cardiac output and intra-luminal pressure changes. It has long been postulated but never proven that such additional stresses strongly influence individual orthostatic tolerance.

Two hundred and twenty-three subjects were subjected to a standard 20-minute tilt table procedure with no intravascular cannulation. Eight per cent experienced syncope or presyncopal symptoms. Of these subjects, a group of 70 underwent a similar tilt table procedure while fully instrumented with an intra-arterial needle and an intravenous catheter. Continuous venous and arterial pressure was measured and repeated cardiac output determinations were made. Forty-six per cent of these subjects experienced syncope or presyncopal symptoms.

It is clear that intravascular instrumentation markedly diminished individual orthostatic tolerance. Data is presented to delineate the cardiovascular hemodynamic changes responsible for this effect, and separate them from those usually seen following orthostatic intolerance due to cause other than instrumentation.

Cardiovascular Response to Acceleration ($+G_x$) in Unanesthetized Normal and in Cardiac Denervated Dogs.

H. L. STONE, Ph.D., and CAPT. EUGENE DONG, JR., USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

Using sterile surgical techniques, a polyvinyl catheter was chronically implanted in the right atrium via the right jugular vein in adult mongrel dogs. Two of these animals had previously undergone cardiac denervation 6-8 months prior to experimentation using an auto-transplant technique. The animals were trained to recline on their backs in the $+G_x$ position in a dog couch using minimum restraint about all four limbs. Heart rate and right atrial pressure were monitored on an Offner Dynagraph recorder. Two Statham pressure transducers were mounted on the dog couch, with one transducer being attached to the animal's chest at the physiological reference point and the other zeroed at this same point and connected to the indwelling catheter. The normal animals were subjected to 2, 3, and 5 $+G_x$ for a period of 60 seconds and the two cardiac denervated animals to 2, 3, and 5 $+G_x$ for 30 seconds.

At the end of one minute, the normal animals exhibited an average increase in heart rate of 8 per cent at 2 G, 12 per cent at 3 G, and 33 per cent at 5 G. At thirty seconds, these same animals had an average increase in heart rate of 6 per cent at 2 G, 8 per cent at 3 G, and 25 per cent at 5 G. The denervated animals had an average increase in heart rate at 30 seconds of 7 per cent at 2 G, 10 per cent at 3 G and 4 per cent at 5 G. The heart rate response on a beat-to-beat basis was extremely stable in the denervated animals as opposed to the instability of the control animals. In the normal animals, the right atrial pressure did not increase at either 2 or 3 G, but did increase an average of 5 mm. Hg at 5 G. The same pattern was observed in the denervated animals with an increase of 1 mm. Hg at 5 G.

The Limitations and Reliability of the Human Operator of Control Systems to Process Information.

J. SZAFRAN, Ph.D., The Lovelace Foundation, Albuquerque, New Mexico.

It is argued that practical problems in the field of aerospace psychology can and should be approached on two levels—the empirical as well as the theoretical. Even although in a number of important areas rationalization has still to remain largely a matter of opinion, there exists a body of knowledge about human performance which is specific enough to be applied in aerospace medicine.

The extent to which man can abstract information from a wide variety of sensory inputs is impressive, even if for some purposes intensive training has to precede efficient performance. Studies of decision processes in perception under reduced signal-to-noise ratio conditions suggest that some of this information may be wholly or in part redundant. However, the provision

of redundant input, apart from guarding against the possibility of the more serious kind of loss of information in adverse conditions, enhances anticipation and prediction, thus promoting foresight and advanced planning of action. It can be shown that it also has the effect of raising and/or maintaining the overall level of "vigilance." Although there are good reasons for regarding the central nervous system as a "channel of limited capacity," experiments show that a well-trained operator is remarkably tolerant of "information overload," even in what is classically regarded as the inevitably "disintegrating conditions" of fatigue. This "spare channel capacity" could in practice be appraised by the introduction of secondary tasks (making them appear, wherever possible, as an integral part of the total task load), which would show how under inconstant environmental conditions the pilot of a space vehicle changes his rate of gain of information and the amount of anticipation. It does not seem wholly implausible to imagine that the cerebral mechanism of his decisions must have sufficient "plasticity" to permit some degree of variation in the details of executive responses for maximum efficiency. Certainly the evidence for "relative functional decortication" is, on closer inspection, quite unimpressive. However, some recent experiments indicate that a reduced rate of cerebral blood flow may affect this flexibility.

It is concluded that the key notion in the appraisal of operational reliability of man in space should be endurance—in the sense of a capacity to adapt rapidly to changing requirements and strange conditions, as well as a general willingness to plan the effort so as to maximize the likelihood of sustained performance.

The Fail-Safe Approach to Human Factor Problems. RAYMOND M. TAMURA, M.D., Honolulu, Hawaii.

Fail-safe practices in design and engineering of aircraft and subsystems have become routine. But similar practices in human factors have not been initiated. Several examples pertaining to human factors in specific situations point to a philosophy almost diametrically opposed to the fail-safe concept. Emphasis has been placed on the fact that pilots and other aircrew members are not always at peak efficiency and health. Human inadequacies under specific conditions have physiological and psychological bases which cannot be overcome even though the pilot is of sound mind and body. Flying high performance aircraft in clear air or storm turbulence has been taken as an example in which detailed analysis of the human factors problem can be done. The Shannon-Wiener measure of information has been evoked to quantify some of the problems. The Shannon-Wiener formulation has been differentiated to present the dynamic situation. A scheme which will provide a fail-safe solution to human factor problems in turbulence has been devised.

Analytical Gas Desorption Apparatus. W. H. TOLIVER, SR., R. E. BENNETT, and C. G. ROACH, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

The most widely used analytical sampling procedure for volatile organic trace contaminants in spacecraft, evaluators, and other closed cabin atmospheres, is based upon their adsorption on active carbon. This paper describes the material, components, and techniques of a chemical high vacuum system for the manipulation of volatile compounds for the desorption and fractionation of analytical samples for qualitative instrumental analysis.

The advantages, disadvantages, limitations, and extended applications of this technique are discussed.

The Influence of Activity and Inactivity on Orthostatic Tolerance and Plasma Volume During Water Immersion for Six Hours with Balanced Pressure Breathing. CAPT. D. E. TORPHY, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

In previous water immersion studies, it has been reported that subjects exhibited orthostatic intolerance following a period of total and/or head-out immersion in 6-8 hours. It was thought the reason for the orthostatic intolerance was primarily due to the negative pressure breathing, leading to diuresis, reduction in plasma volume and subsequent responses on the tilt-table. In the experiments being reported upon, subjects were immersed in water but breathing pressures were balanced to the subject's mid-thoracic level. Five separate experimental procedures were conducted on five human subjects. Diet and time of day were the same for each subject for each procedure. They were as follows: (a) A six-hour period of normal activity. (b) A six-hour period of bed rest and inactivity. (c) A six-hour period of bed rest with 90 seconds of activity every 15 minutes. (d) Two six-hour periods of recumbent immersion with no activity. (e) A six-hour period of total recumbent immersion with 90 seconds of activity every 15 minutes.

Pre- and post-immersion plasma volume changes and response to tilt were measured and changes in heart rate and rhythm were monitored during the immersion period from the electrocardiogram as was breathing pressure. Urinary noradrenalin excretion during prolonged tilting following immersion while inactive was also determined and compared to similar data following normal activity and bed rest while inactive.

Problems in Air Traffic Management. VII. Job and Training Performance of Air Traffic Control Specialists—Measurement, Structure, and Prediction. DAVID K. TRITES, Ph.D., CLINTON E. MILLER, Ph.D., and BART B. COBB, M.S., Office of Aviation Medicine, FAA, and Biostatistical Unit, University of Oklahoma Medical Center, Oklahoma City, Oklahoma.

To evaluate performance of Air Traffic Control Specialists in training at the FAA Academy, 24 measures of achievement and potential were developed. Following a principal component factor analysis and varimax rotation of the factors, 5 interpretable performance dimensions emerged in 5 separate samples of ATCS trainees representing the 3 ATCS occupational options. These dimensions represented performance in the simulation laboratories, intermediate and final academic performance, and 2 different types of ratings made by course instructors. From a similar factor analysis and rotation of 16 measures of job performance, 6 interpretable performance dimensions emerged from 4 separate samples of ATCS trainees representing the Enroute and Terminal ATCS options. These 6 dimensions, based upon ratings by job supervisors, were considered to measure an overall opinion of the individual, his interpersonal orientation, job performance, job orientation, job potential, and emotional stability. Examination of the relationships between the training performance measures and job performance measures revealed that the relationships differed as a function of which ATCS option was being considered. For example, academic grades could be used to predict the overall opinion of an individual by his job supervisors among Terminal ATCS trainees, but not for Enroute trainees. Conversely, training laboratory performance grades could be used to predict the overall opinion of an individual by his job supervisors among Enroute trainees, but not for Terminal trainees. From these findings, it was concluded that either the superficially similar training performance measures found in the three types of training courses (*i.e.*, Enroute, Terminal, and Flight Service Station) may have different meanings for the different courses, or that the superficially similar job performance measures represent different aspects of job performance according to the type of facility from which ratings were obtained.

Airsickness in Student Aviators. LT. G. J. TUCKER, MC, USNR, LT. D. J. HAND, MC, USNR, LT. A. L. GODBY, MC, USNR, and CAPT. R. F. REINHARDT, MC, USN, Naval School of Aviation Medicine and Naval Auxiliary Air Station, Saufly Field, Pensacola, Florida.

During the training of aviators, airsickness presents as a complex nexus of physiologic and psychologic factors. In an effort to determine the significance of airsickness, a large group of student aviators was surveyed.

One thousand sixty-seven student naval aviators were rated at the end of each flight during the pre-solo and basic acrobatic phase of training by the flight instructor for the presence or absence of nausea or vomiting during that flight. To be so rated, the airsickness had to be severe enough to cause inability to

control the aircraft. In this manner, a profile of the patterns of airsickness was obtained on each student over the course of the basic flight training.

The incidence of this type airsickness was 17.6 per cent (188 students out of 1,067). Correlations between incidents of airsickness per student and their ground school grades and flight grades were not statistically significant. The patterns of this airsickness are described and correlated with the physiologic and psychologic stresses during this basic phase of training.

The students dropped from the program during the time period of the stndy for intractable airsickness was 2 per cent (0.3 per cent of the total population surveyed). The clinical psychiatric profile of these dropped students is compared to the students who had excessive airsickness (total incidence more than two standard deviations from the mean) but were not dropped from the program.

The incidence and natural history of airsickness have been defined in a large group of student aviators. In most cases, airsickness is a self-limited problem. The statistical data and the clinical psychiatric profiles of the dropped and adapted students provide useful baselines for the separation of physiologic and psychologic factors in the future evaluation of student aviators.

Cardiovascular Effects of Rotation in the Z Axis. Capt. Charles W. Urschel, USAF, MC, and Capt. William B. Hood, Jr., USAF, MC, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Rotation of the seated subject about the Z axis (R_Z) results in a radical acceleration gradient which inhibits venous return thereby representing a cardiovascular stress. Five subjects were studied, each undergoing four possible rotational profiles combining two rates of angular acceleration (0.1 and 0.8 radians per second per second) and two rotational speeds (60 and 120 RPM). There was a three minute plateau at peak rotational speed. Heart rate and arterial and venous pressures were measured with indwelling catheters. Pressures were referenced to right atrial level at the center of rotation which was placed in mid-chest. Centripetal acceleration at hand/foot radius (0.5 meters) was 1.8 and 7.4 G at 60 and 120 RPM respectively.

Rotation at 60 RPM after slow and fast angular acceleration resulted in no significant cardiovascular decrement. Three-minute 120 RPM runs, however, caused progressive tachycardia, narrowing of pulse pressure, and a drop in mean arterial pressure. Petechiae were seen on hands and feet of all subjects at 120 RPM. Relative bradycardia with collapse of arterial blood pressure occurred in one subject following head movement. It is known that for short term rotation, vestibular effects resulting from angular acceleration either directly or reflexly limit tolerance. The present study shows that for long periods and higher rates of rotation the cardiovascular effect becomes predominant.

Efficacy of Air Cooling Systems in Pressure Suits in Hot Environments. Capt. James H. Vegte, USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Three different air distributing systems were evaluated in full pressure suits under two conditions: with the suit unpressurized and with the suit pressurized at 190 mm. Hg. Three sitting, resting subjects were exposed under each condition to a temperature of 43°C. at normal barometic pressure for a period of two hours or until tolerance was reached. The air temperature and mass air flow delivered to each ventilating system was constant at 21°C. and 173 g/minute respectively. The separate tubular air ventilating garment was equal to or superior in evaporating cooling efficiency to either an extremity dumping system which is an integral part of the current operational suit or to the standard Air Force ventilating garment worn under the pressure shell. When pressurized, the amount of sweat evaporated compared to the total produced was reduced with all ventilating systems although the total quantity of sweat increased. Skin and rectal temperatures and heart rates were increased under pressurized conditions. In these experiments, body storage rates varied from 0 to 30 Kcal/m² hour. These data indicate the superiority of a separate tubular air ventilating garment for evaporative cooling under these conditions over the other delivery systems. Pressurization decreases evaporative cooling because of the increased air volume under the pressure shell which reduces air turbulence. In the event of suit inflation and extended high heat loads, the magnitude of the sweat loss could become a critical factor.

A Method for Recording Body Temperature for Prolonged Time. Michael A. B. Vianello, B.A., and Donald I. Tepas, Ph.D., MPG Research Laboratory, Honeywell, Inc., St. Paul, Minnesota.

Russian experience indicates that a harness system of fastening electrodes provides a comfortable and reliable method for obtaining electrocardiogram signals during prolonged space flight. Adopting a similar approach, a harness-mounted temperature sensor was developed. The sensor consisted of nickle-iron wire sealed between two layers of teflon-backed adhesive tape. This temperature sensor was 30" by 1" in size and was mounted in an adjustable elastic harness which held the sensor in close contact with the chest. The hypothesis was made that a large-surface sensor worn in this manner would provide a comfortable, reliable, and sensitive technique for recording skin temperature.

Using this system, temperature measurements, together with concomitant heart rate readings, were made on 23 subjects in the course of 48-hour experimental sessions. The harness proved to be a reasonably comfortable item. No medical complications of any sort developed from wearing the harness. The circuit used in this study enabled us to make temperature measurements to the nearest 1/10th of one degree Fahrenheit. The temperature readings appear in agreement with the literature: (1) temperature readings display prominent circadian rhythms with the lowest temperatures being recorded in the early morning hours; (2) temperature increased as the subjects appeared to sleep; (3) heart rate changes agree with the temperature changes observed.

The temperatures recorded in the manner described appear to be comparable to standard methods of body temperature recording. The comfort and reliability of this system suggests that it might be used to monitor body temperature changes remotely in the course of extended space travel.

Waste Management System for Aerospace Stations. H. Wallman, M.S., J. L. Dodson, M.S., and D. Rosen, B.A., General Dynamics/Electric Boat, Groton, Connecticut.

An engineering evaluation was conducted to select an optimum waste management system for collection, storage, and/or disposal of feces and urine in a space station under weightless conditions. Mission parameters considered were 6 to 21 crew members for 14 to 30 days. The techniques considered were: (1) mixed urine and feces—freeze dried, (2) mixed urine and feces—freeze stored, (3) mixed urine and feces—biodegradation, (4) mixed urine and feces—vacuum distilled with vapor pyrolysis, (5) mixed urine and feces—heat sterilized or disinfected and stored, (6) mixed urine and feces—sterilized and vented, (7) feces collected in bags—incinerated, (8) feces collected in bags—sealed storage in cans, and (9) feces combined collection and storage—partial drying by space vacuum. Evaluation was based on total weight (including penalties for power, heat rejection and cabin air loss), volume, reliability, plus several other factors. The optimum system consisted of feces collection, partial dehydration and storage in one piece of equipment with no transfer or handling; urine is collected and treated separately.

Tests performed with a breadboard model of the feces collector demonstrated the feasibility of the recommended approach with regard to: (a) lack of pressure buildup with partially dehydrated feces, (b) satisfactory odor removal from recycled air, and (c) complete bacterial removal from vented gases.

Determination of In-Flight Biochemical Responses Utilizing the Parotid Fluid Collection Technique. CAPT. B. W. WARREN, USAF, MC, MAJ. R. W. WARE, USAF, MC, MAJ. I. L. SHANNON, USAF, DC, and S. D. LEVERETT, JR., Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The analysis of human biochemical responses to the inflight conditions of high performance jet aircraft has lagged far behind other in-flight biochemical monitoring methods. Much of the reason for this lies within the inherent dangers, discomforts, and logistic problems involved in collecting in-flight specimens of blood and urine, which are the usual materials utilized for the biochemical analysis of such responses.

The correlation between serum and parotid fluid levels of many specific biochemical substances has been well substantiated in extensive previous studies. For example, rises in the serum levels of free 17-Hydroxycorticosteroids are reflected by proportional and rapid increases of these substances in parotid fluid secretions. Such corresponding rises occur after analogues of hydrocortisone are administered by oral or parenteral routes or when the adrenal glands are stimulated by the administration of ACTH. The value of measuring the levels of such biochemical substances during the stressful conditions of flight is obvious.

Experiments involving the in-flight collection of parotid fluids from subjects flying in the USAF School of Aerospace Medicine F-100 jet fighter-bombers were initiated in November 1962.

In-flight parotid fluid collections have been made from 22 volunteer subjects during more than 150 aircraft sorties. Improvements in technique now assure nearly 100 per cent collection success under all flight conditions. Present studies involving this procedure will be discussed.

A Bioengineering Approach for Defining the Functional Requirements for Trace Contaminant Control in Space Stations. T. B. WEBER, Ph.D., and CHARLES SPEZIA, B.S., Space Engineering Dept., Beckman Instruments, Inc., Fullerton, California.

Current research in atmospheric and waste contamination has resulted in a list of anticipated contaminants in manned space vehicles. Although a comprehensive listing is not available, known components of significance are being defined and indications of anticipated loadings are being considered. Based on empirical calculations in conjunction with laboratory studies, it is now possible to tentatively characterize the type of hazard caused by the prospective materials. Each specific contaminant can be assigned to one of five categories: 1) fire and explosion, 2) acute or 3) chronic toxicological exposure, 4) allergic reaction, 5) odor and taste. Key trace contaminants have been selected and examined according to this protocol. Those which presently seem to be most significant for intermediate and long-term space measurements include hydrogen, acetone, ammonia, carbon monoxide, methane, and low molecular weight alcohols. Tentative findings have been reached concerning contaminant synergism and antagonism, comparative toxicity, buildup rates and extrapolation of industrial values.

The effects of aerospace environmental parameters, such as reduced total pressures, increased oxygen and weightlessness, on the maximum allowable concentration values have also been considered. Meaningful values are presented to establish both the functional requirements and performance specifications for contaminant control systems. Such systems will effectively operate to maintain contaminant concentrations below levels which constitute the limiting value for each hazard category. A monitor readout mechanism is proposed that displays a simple visual indication for the cumulative contaminants.

A Model for the Study of Psychological Stress. LT. ROBERT J. WHERRY, JR., MSC, USN, U.S. Naval School of Aviation Medicine, Pensacola, Florida.

An operator's reactions to the threat of impending disaster may well account for more variance in performance among aviators and astronauts than their susceptibility to all of the physical and physiological stressors combined. Susceptibility to psychological stress, especially during critical periods of a mission, such as re-entry, may be the deciding factor between success or failure of a mission. Development of methods of identifying persons who will suffer no deterioration of performance on complex tasks under threatening conditions is discussed.

A theoretical model, with which psychological stress may be systematically explored, is presented. The model discusses the roles of such determiners of psychological stress as (a) the perceived probability of the occurrence of unpleasant events, (b) the perceived proximity of the occurrence of unpleasant events, and (c) the perceived degree of unpleasantness associated with possible events.

Types of experiments which could be used to study this area are described.

The Effects of Transient Weightlessness on Brightness Discrimination. W. J. WHITE, Ph.D., Missile and Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, California.

Contrast thresholds of six semisupine, visually adapted subjects were obtained under short (10-15 sec.) periods of weightlessness and under 1 G control conditions. The target, viewed binocularly, subtended 1.5° and the background 2.6°. Three background luminance levels were used: 0.03, 0.28 and 30.0 ft-L. The contrast required to detect the target was found to be slightly, but consistently, lower under the weightless condition than under the control, 1 G, condition. Under the weightless condition the contrast required to detect the target averaged 12.56 per cent at 0.03 ft-L background luminance, 6.4 per cent at 0.28 ft-L background luminance and 3.99 per cent at 30.0 ft-L background luminance. The corresponding contrasts required under the control, 1 G, condition averaged 15.14 per cent, 7.05 per cent and 4.45 per cent respectively.

Distant Visual Acuity and Civil Aeromedical Standards. ROBERT L. WICK, JR., M.D., The Garrett Corporation, Los Angeles, California.

The present aeromedical standards concerning distant visual acuity have evolved over a number of years since the first standards were set up in 1926 by Dr. Louis H. Bauer. The history of these standards bears little relation to the various studies performed over the years relating distant visual acuity to aircraft accident rates. The changes in these standards, the marked differences between the standards as printed in the Federal Air Regulations and the actual policies used in carrying out these regulations, and the rationale behind these policies are discussed. A number of studies, previously unpublished, of aircraft accident rates and their relationship to medical standards for distant visual acuity are included.

Growth Responses of Vascular Plants Under Exotic Atmospheres. S. S. WILKS, Ph.D., USAF School of Aerospace Medicine, Brooks AFB, Texas.

The growth rates of the giant duckweed (*Spirodela polyrrhiza*) and three common garden vegetables (Chinese cabbage, Swiss chard, and turnips) were measured by increases in dry weight and oxygen production under a series of different total pressures and gas mixtures consisting of oxygen, nitrogen, carbon dioxide, helium, and argon. Data will be presented showing the growth response of these plants under gaseous environments which may be similar to those used by astronauts in extraterrestrial environments.

Soviet High Altitude Pressure Suit Development, 1934-1955.

MAJ. CHARLES L. WILSON, USAF, MC, Air Force Systems Command, Andrews AFB, Washington, D. C.

Careful analysis of a country's progress in high altitude pressure suit development and testing proves to be an excellent indicator of that country's technological growth and maturity in aerospace medicine. It also provides much information about performance of the associated aerospace vehicles. Before 1957 Western aerospace medical scientists have been generally unaware of the solid technological base which their Soviet counterparts developed prior to and immediately after World War II in this field. This general Western ignorance of early and impressive Soviet accomplishments was due mainly to lack of interest and lack of awareness of abundant well translated open source literature in this area for this time period.

A review has been made of all available open source Soviet aerospace medical reports on high altitude pressure suits for the period 1934-1955. The U. S. Library of Congress and Department of Commerce were particularly excellent sources for this period. The conclusions from this review are as follows:

a) As early as 1935 Soviet aerospace medical physicians and physiologists had a clear grasp in depth of extreme high altitude physiology. As early as 1935 they clearly understood and applied the discoveries of P. Bert, J. B. Haldane, J. Jongbloed, H. G. Armstrong, Y. Henderson, J. Barcroft and others toward solving pressure suit development problems. Despite the confusion of V. V. Streltsov, all other prominent Soviet aeromedical physiologists appreciated the beneficial effects of breathing 100 per cent oxygen toward reducing or eliminating dysbarism due to evolved nitrogen. Their own inhouse research before 1940 led them to conclude that Haldane's rule of thumb that a 2 to 1 pressure drop without denitrogenation was too conservative. They adopted a 2.24 to 1 rule. This has very important implications for space vehicle design.

b) In 1934 the Soviets embarked on a full pressure suit development program which was exceptionally well organized, staffed and funded for that decade. By 1940 they had developed advanced types of altitude suits which had been extensively tested including many exposures to 87 mm. Hg. (15.2 km.) on a closed circuit system, parachute jumps, and several high altitude flights. No other nation had such a far advanced program at that time. Photographs of these prototype suits and closed circuit systems are presented and discussed.

c) Several early and excellent translated documents on Soviet aviation medicine, complete with photographs and bibliographies have been rediscovered.

An assessment of a nation's technological foundations is of utmost importance in deducing the strengths and directions of later research and development.

Upper Thermal Tolerance Limits for Unimpaired Mental Performance.

JOHN F. WING, M.A., Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Physiological tolerance limits for men exposed to high ambient temperatures have been available for nearly two decades. It has long been suspected, however, that human performance deteriorates before these physiological limits have been reached. The present study reviews fourteen experiments on the effects of high temperatures on mental performance and shows conclusively that deterioration occurs well before the recommended physiological limits. Besides a brief resumé of each study, the present paper provides a graphic summary in the form of a temperature-duration tolerance curve. This curve is based on the composite results of all fourteen studies and shows those temperature-duration combinations where there is a statistically-reliable performance decrement. At every point the performance limit is reached before the physiological limit is reached. As an example, at 31.7°C. (89°F.) effective temperature the recommended (tolerable) physiological exposure limit is four hours, whereas a statistically significant deterioration in mental performance occurs after only two hours of exposure. The importance of the present review lies in its specification of where (between the comfort and physiological thresholds) deterioration in mental performance occurs. Although this proposed tolerance curve for mental performance will be continuously modified by the results of additional studies, it nevertheless provides a first step in filling a gap in our knowledge of man's response to thermal stress.

A Telemetry System for the Acquisition of Circadian Rhythm Data.

C. M. WINGET, Ph.D., and T. B. FRYER, B.S., NASA Ames Research Center, Moffett Field, California.

Pathophysiological disturbances evidenced after sudden changes in the environment may be the result of shifts in physiological rhythms (asynchronous rhythms). Pilots and spacemen are subjected to relatively sudden changes in external cycles (light-dark cycles) which may result in confusion, fatigue or even death. The experiment reported upon herein was designed to obtain Circadian rhythm data. A module assembly designed to maintain an unrestrained experimental animal and to collect data on four Circadian rhythms is presented. Two radiotransmitters coupled to a digital print-out system are employed; one is for the continuous monitoring of heart rate (ECG) and the other for recording deep body temperature. The locomotor activity and frequency of the female bird's sexual cycle is also recorded. Most of the electronic equipment and animal requirements (feed, water and fresh air) are incorporated into the module assembly which is shielded to minimize any interference on the radiotransmitters. Quantitative evaluation of locomotor activity is accomplished by recording the change in force on a strain gauge exerted by the animal on the cage floor. The sexual cycle is measured by recording the time of oviposition. Changes in deep body temperature are measured with a thermister contained in the implanted transmitter assembly. The ECG is obtained with subcutaneous electrodes, measuring changes in surface potentials, which are then amplified and telemetered with a transmitter. The periodicity of the data is established by the correlogram and periodogram methods. Power spectral analysis and periodic regression techniques are used to further describe the collected data. Analysis of the data reveals Circadian cycles as well as poorly defined ultradian cycles.

Respiratory Water Loss.

E. C. WORTZ, Ph.D., The Garrett Corporation, Los Angeles, California.

A summary of lengthy experiments on water transfer during respiration will be presented.

Respiratory water loss was investigated with a group of normal subjects breathing oxygen orally. Data were collected from all subjects under three absolute pressures (3.5, 7.0, and 14.7 p.s.i.), three work rates on a treadmill (0, 2, and 4 m.p.h.), three humidities of the inspired oxygen (40°F., 60°F., and 80°F. dewpoint), and three drybulb temperatures of the inspired oxygen (95°F., 75°F., and 55°F.). The data were analyzed statistically.

All of these variables affected respiratory water loss in varying degrees. Reduced pressure diminished respiratory water loss, apparently because of a corresponding decrease in minute volume observed at lower pressures. Increased work rates elevated pulmonary ventilation and thus increased respiratory water loss. Increasing humidity decreased water loss, while increasing drybulb temperature produced greater water loss. Expired gas temperatures approached body temperature only at elevated inspired temperature; the expired gas volume was never saturated.

Investigations in Human Tolerance to Lateral Impact.

CAPT. ALBERT V. ZABOROWSKI, USAF, MC, CAPT. JERRY D. ROTHSTEIN, USAF, MC, and CAPT. WILLIAM K. BROWN, USAF, MC, Aeromedical Research Laboratory, Holloman AFB, New Mexico.

Complete investigations on the effect of basic restraint systems and their protection in lateral impact studies with human subjects is lacking in the literature. To provide basic information, a series of controlled deceleration experiments was performed with human volunteers restrained with a lap belt and repeated with a lap belt and over the shoulder harness attaching to the lap belt. Human tolerance based on body kinematics is at the 9 G input level and impact durations of 0.1 sec. at that level for the lap belt only configuration and at the same level and input condi-

tions for the lap belt-shoulder harness configuration where tolerance is based on subject discomfort with prolonged stiffness and soreness in the neck musculature.

Air Force Aircraft Disaster Accidents.

ANCHARD F. ZELLER, Ph.D., Life Sciences Division, Office of the Inspector General, Norton AFB, California.

Disaster-type aircraft accidents involving ten or more fatalities, although far less frequent than accidents involving fewer casualties, command attention because of the publicity that they receive. They also demonstrate the threat ever inherent in air travel. During a ten-year period, the Air Force experienced 81 such accidents that resulted in over 1,600 fatalities. By far the greater number of these accidents involved cargo-type aircraft, although a few bombers and still fewer fighters and trainers were involved.

The causes of these accidents, together with associated conditions, were considered. Efforts conducive to the prevention of these major disasters are equally applicable to the less dramatic accidents that erode the Air Force capability to a greater extent by virtue of their larger numbers and greater collective cost.

A Comparison of Drug-Induced Performance Decrements in Aircraft and Instrument Flight Trainer.

JOHN F. ZIEGLSCHMID, M.D., CHARLES E. BILLINGS, M.D., and JACK J. EGGSBUEHLER, M.Sc., Department of Preventive Medicine, The Ohio State University, Columbus, Ohio.

The effect of the synthetic versus operational flight environment on pilot performance was assessed utilizing highly-skilled professional pilots. Two-hour instrument flights in both an aircraft (C-45) and instrument flight trainer (Curtiss-Wright Dehmel P-3A) were performed under matched, double-blind, and replicate exposure to drug (secobarbital) and control (lactose). The following performance parameters were measured during cruise and approach by electronic integration: 1) VOR tracking error; 2) Altitude error; 3) Localizer and glide path error.

Under the experimental conditions the following statistically significant results were obtained:

1. The aircraft was a more sensitive indicator of drug-induced performance decrements than the instrument flight trainer.
2. Performance variability was greater in the aircraft under both drug and control conditions.
3. VOR tracking was an insensitive measure of piloting proficiency.
4. Altitude-holding function was a sensitive index of performance decrements during cruise flight.
5. ILS approaches were significant indicators of drug-induced performance decrements in the airplane but not in the flight trainer.
6. Both horizontal and vertical axes of the ILS must be recorded simultaneously if performance decrement is to be detected under all conditions.

Further comparative investigations of flight trainers as laboratory research tools appear warranted, particularly since the performance obtained in the flight trainer was qualitatively similar to the aircraft. This study has shown that extrapolation of experimental findings generated in a synthetic environment to the operational environment is hazardous in the present state of the art.

Studies of Oxygen Toxicity in the Central Nervous System.

L. G. ZIRKLE, C. E. MENGEL, M.D., B. D. HORTON, and E. J. DUFFY, Department of Medicine, Duke University, Durham, North Carolina.

In our previous studies of mice exposed to oxygen under high pressure (OHP) we showed that mortality and convulsions were increased in tocopherol-deficient mice and decreased by pre-OHP administration of tocopherol (a lipid antioxidant). This suggested that lipid peroxidation was involved in CNS damage by oxygen.

In the present study tocopherol-deficient and tocopherol-supplemented mice were exposed to 100 per cent O_2 at 3 Atm. for 60-90 minutes. Convulsions (time of onset, frequency) and mortality were noted. After OHP, brains were quickly frozen (to prevent *in vitro* lipid peroxidation) and analyzed for lipid peroxide content and acetylcholinesterase (AChE) activity.

Convulsions during OHP occurred sooner in tocopherol-deficient mice (16 minutes) than in tocopherol-supplemented mice (no convulsions before 80 minutes). Mortality of tocopherol-deficient mice was higher than tocopherol-supplemented mice (68/72 vs. 39/103). No lipid peroxides were demonstrated in brains of either group before OHP. After OHP lipid peroxide levels in brains of tocopherol-deficient mice were higher than in tocopherol-supplemented mice (18.1 vs. 5.7 units). Average brain AChE activity of mice not exposed to OHP was 7.2 enzyme units (Eu). After OHP, brain AChE activity of tocopherol-deficient mice (5.7 Eu) was lower than tocopherol-supplemented mice (7.2 Eu).

These studies showed that clinical features of CNS oxygen toxicity correlated with increased lipid peroxide content and decreased AChE activity of brains. The data is consistent with the hypothesis that hyperoxic convulsions may be due to inhibition of brain AChE activity (known to cause convulsions) by lipid peroxides (known to inhibit AChE) formed *in vivo* during OHP.

Abstracts Received After Deadline for Alphabetical Listing

Medical Evaluation of Airmen Exposed to Altitudes in Excess of 50,000 Feet.

CHARLES I. BARRON, M.D., and ALBERT H. SCHWICHTENBERG, M.D., Lockheed-California Company, Burbank, California, and Lovelace Foundation, Albuquerque, New Mexico.

Numerous military and civilian pilots have been exposed to altitudes in excess of 50,000 feet during both test and operational aircraft flights. While exposures in some cases have been of short duration, a significantly large number of pilots have accumulated hundreds of hours in repeated exposures over periods of six months to more than four years. This select group of airmen has been under close medical surveillance, and sufficent data have now been accumulated to warrant some generalizations concerning the biomedical aspects of high altitude flight.

This paper presents the findings in a representative sampling of pilots, who periodically completed a comprehensive medical evaluation, including detailed ophthalmological studies, extensive biochemical determinations, physiological testing, and total body radiation measurements. Detailed family histories are also reported.

The findings in this group are compared with a control group consisting of pilots with no significant exposure at the higher altitudes. It is believed that the results of this survey are significant in their application to future manned high altitude military and civilian aircraft flight.

Permissible Radiation Contamination Levels in Manned Spacecraft.

E. N. CARLSEN, Ph.D., and T. B. WEBER, Ph.D., Beckman Instruments, Inc., Fullerton, California.

Long-term subsistence of man in space depends on the ability to exist and perform useful functions in a foreign environment. The effects and interactions of prolonged zero gravity, confinement, acceleration, vibration, variations in total pressure and gaseous composition, as well as emotional stresses in conjunction with radiation exposures, must be considered. Widespread usage of isotopes for gathering scientific data constitutes a necessary biomedical research area. A means of facilitating data acquisition of variables will be by radioisotope-tagged metabolites. Calcium-45, for example, can be used to study bone kinetics; carbon-14 cortisol and tritiated aldosterone for secretion rates; I-125 thyroxine for studies on thyroid function and I-125 serum albumin for the measurement of blood volume.

The use of isotopes in the confines of a spacecraft poses an obvious threat to the accidental contamination of the craft. It is necessary, therefore, to consider the establishment of a maximum allowable contamination. Factors such as half-life of isotope,

energy and type of radiation, area of contamination, partial pressure of the tagged compounds, etc., must be considered in establishing this contamination level. A working hypothesis can be formulated for considering the environmental parameters. Based on such mathematical models, it should be possible to establish radiological safety techniques which would serve as guidelines for the successful application of isotopes in life support studies.

Rapid Decompression Hazards Following Exposure to a Mixed Gas Spacecraft Atmosphere.

CDR. MORRIS J. DAMATO, MSC, USN, LT. GARY L. KELLETT, MC, USN, and CDR. KENNETH R. COBURN, MSC, USN., Naval Air Engineering Center, Philadelphia, Pennsylvania.

The investigation reported herein is an extension of a program conducted previously at the Aerospace Crew Equipment Laboratory to determine the decompression hazard associated with a mixed spacecraft atmosphere. The initial study was extended to substantiate the required times for equilibration (partial denitrogenation) at the test atmosphere which will provide protection against bends following a rapid decompression to 35,000 feet. Twelve test subjects participated in a total 103 man ascents to 35,000 feet following varied exposure times to a 50% oxygen-50% nitrogen atmosphere. Results of this investigation substantiate the findings of the previous study, namely breathing 100% oxygen for at least 3 hours at sea level or breathing a 50% oxygen-50% nitrogen gas mixture for about 18 hours, or more, at an altitude equivalent of 18,000 feet will reduce the incidence of bends. About 8% of the exposures to the test atmosphere at 18,000 ft. resulted in bends.

Possible Physiological Effects of Long-term Weightlessness on Man.

VINCENT M. DOWNEY, M.D., and CLARENCE C. CAIN, M.S., Lockheed Missiles and Space Company, Sunnyvale, California.

Many unknowns remain in weightlessness. The major questions concern the long-term effects. Fully realizing the possibilities for error, a projection of the possible effects of prolonged weightlessness upon man will nevertheless give us some idea what to expect in future manned orbital flights.

Two sources of such information exist today. The first is the few "hard" data available from the reports of the Mercury and Vostok flights (lasting from one and one-half hours to five days), and the earlier animal suborbital and orbital flights, notably the six-day flight of Laika. These data showed that man can adapt to short-term zero-g exposures. However, extrapolation of the data is a hazardous scientific venture. For example, much of the information obtained from parabolic aircraft flights has been shown to be due to changing or transitional acceleration, rather than to weightlessness itself.

The other source of information at hand is the data from simulation devices. Laboratory experienments in analogues of weightlessness have shown some effects on various organs. All such analgoues are open to question. Conclusions based on these experiments may be in error. It is simply impossible to simulate weightlessness in the laboratory.

Effects on each organ system will be examined separately. The possible effects *during* long-term exposure to weightlessness will be considered first. Next, the possible effects *after* exposure to long-term weightlessness will be presented.

Training the Vestibule for Aerospace Operations: I, Using Coriolic Acceleration to Assess Rotation.

CAPT. KENT K. GILLIGHAM, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

It is common knowledge that the semicircular canals, once they have equilibrated to an angular velocity, cannot respond to that motion, be it pitch, roll, or yaw.

By employing self-induced coriolis stimulation, however, one can perceive otherwise undetectable rotation. How accurately this can be done was studied by determining the psychophysical functions for the discrimination of direction of rotation at different yaw velocities. We have found that subjects with minimal training can perceive accurately angular velocities slower than the standard four-minute turn of instrument flight, despite the fact that velocities of much greater magnitude remained unperceived until the coriolis acceleration was induced.

The potential use of this and similar maneuvers as a means of countering spatial disorientation is discussed.

Sonic Boom, People and SST Operations: A Status Report.

CHARLES W. NIXON, Ph.D., Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio.

Since the emergence of the sonic boom in the late-1940s as an unavoidable companion of supersonic flight a number of noteworthy programs have been accomplished to identify the nature of the sonic boom and its impact on aviation and people. National and international interest in a commercial supersonic transport has led to several studies and evaluation approaches to consider the definition and solution of sonic boom problems in planning SST operations. This paper discusses the experimental and operational sonic boom experience prior to and including the recent programs conducted by various agencies in support of current SST-plans (St. Louis, 1961-62; Oklahoma City, 1964; White Sands, 1964-65). Comments are offered regarding current knowledge of individual responses and community reactions to sonic booms of varying parameters. An estimate of the population to be exposed during routine SST operations is noted. Future research is considered in terms of the question, "Are there areas where additional sonic boom research would aid decision making for SST operation and management?"

A Critique of the Biological Significance of the Supersonic Transport Radiation Environment.

MAX M. NOLD, D.V.M., Ph.D., DUANE A. ADAMS, M.S., and IRVING J. RUSSELL, Ph.D., Air Force Weapons Laboratory Kirtland AFB, Albuquerque, New Mexico.

There are several poorly defined aspects of ambient space radiations affecting supersonic flight, which relate to their biological significance. Although the magnitudes of doses expressed in physical units are low, even for transient solar flare encounters, some concern has been expressed by Schaefer, Foelsche, Dye and others concerning the high cell damaging potential of the heavy ionizing component of galactic primary radiations, secondary galactic radiations, and of the alpha particle componet of solar particle eruptions. This paper presents detailed calculations of the primary and secondary particle fluxes to be encountered at 70,000 feet along polar and mid-latitude flight paths; discusses critically the fractional cell lethality concept advanced by Dye *et al;* and outlines a forthcoming experimental program for the measurementof fluxes and linear energy transfer spectra of the biological significant components of 70,000 ft. radiation, using high flying aircraft.