Abstracts of Papers from Scientific Program of 1960 Meeting of Aerospace Medical Association, Miami Beach, May 9-11

Bioenergetics in Space Environment Control. NORMAN LEE BARR, M.D., F.A.C.C., Republic Aviation Corporation, Farmingdale, N. Y.

This paper discusses the critical area of bioenergetics control in space flight and gives results of heat experience in Strato Lab balloon operations above more than ninety-eight per cent of the earth's atmosphere. The mechanism of heat transfer from man to heat sink changes with environmental temperature. When ambient temperature is below 33° C in a pressure of one atmosphere of air, convection and conduction serve as the transfer mechanism, and humidity control is not critical. Above 33° C heat must be transferred by water evaporation on the subject and condensation on the heat sink. In this case, humidity control is critical. When pressure is reduced below one atmosphere, the "cross-over" temperature changes because of reduced heat capacity in the atmosphere. A simultaneous reduction in the moisture capacity of the atmosphere increases the criticalness of the temperature dew point ratio control. The combination can lead quickly to body temperature elevation and death. Heavy penalties in propulsion weight resulting from imbalance of the CO_2 absorption/oxygen supply ratio can be avoided through adjustment to the predicted respiratory quotient. Additional weight savings accrue from advance estimates of metabolic rate based on body surface area and expected energy expenditure profiles.

Recent Advances in the Development of a Closed Ecological System. CAPT. JACK H. BATES, Ph.D., USAF School of Aviation Medicine, Brooks AFB, Texas.

This paper will cover all recent advances in the development of a closed ecological system at the School of Aviation Medicine. It will include advances in photosynthetic gas exchangers, methods of control of contamination in algal systems, techniques for increasing metabolic rates in algae, optimum light sources, and overall system design. Mention will be made of other plants and animals as interposed in a closed system.

Medical Support of ICBM Missiles. BRIG. GEN. T. C. BEDWELL, JR., COL. ALVIN F. MEYER, JR., and LT. COL. G. R. ANDERSON, USAF (MC), Headquarters, SAC OFFUT, AFB, Neb.

Integration of ICBM units into the operational weapons systems inventory has presented special concerns to the medical service of SAC. The majority of medical support considerations are extensions of already existing problem areas or represents situations where either present knowledge may be adapted to provide required action or existing techniques and knowledge may be supplemented to provide the required support. Necessity for development of an operational capability as soon as possible has required increased co-ordination and co-operation among research and development agencies, procurement activities, and the operational command of SAC. Medical service responsibility for health protection and health promotion was recognized early in the developmental phases of the weapon system. Numerous inputs to weapon system requirements were developed by the medical service. These included those relating to the maintenance of the missile system, health and sanitation aspects of the facilities, and requirements for physical standards for missile personnel. Inputs on training directives, and healthy precautionary publications, have also been provided. Operational medical support for missile units differs little in principle from that of all SAC units, and consists of those actions relating to community medicine and mission medicine. Solutions to the problems of medical support for ICBM operations are readily at hand and have been developed. Since the missile represents a step into the true aerospace age and manned space flight, many of the lessons being learned with regard to specialized medical support requirements afford a solid ground work for future medical service evolution.

Human Tolerance to Ultra High G Forces. CAPT. ELI L. BEEDING, JR., USAF (MSC), and MAJ. JOHN D. MOSELY, USAF (VC), Aeromedical Field Laboratory, Holloman AFB, N. M.

Using the Daisy Track at the Aeromedical Field Laboratory, Holloman Air Force Base, New Mexico, as a test facility, human volunteer subjects were exposed to forces of short duration while seated in the backward facing position. Subjects received from 50 G to 83 G without suffering any apparent permanent damage. Experimental parameters such as peak G, rate of onset of G and duration of G are given for several of these experiments. Subjective reaction to these various force level is discussed accompanied by pertinent comments on the influence on human tolerance of subject position and harness.

Dependence of Oxygen Consumption of Mice on Tension and Ambient Pressure. DIETRICH E. BEISCHER, Ph.D., USN School of Aviation Medicine, Pensacola, Fla.

The animals were enclosed at different temperatures in oxygen filled flasks of 1 to 5 liter content. Provisions were made for removal of the exhaled carbon dioxide. To the extent to which the animal consumed oxygen, the pressure in the flask decreased. In a physiological adaptation process, the mouse is able to reduce its metabolism at low ambient pressure to about 1/10 of the sea level value. At this low metabolic rate, the animals lived for periods of several hours at the low ambient pressures. Mice were recovered which had lived at an ambient pressure where tissue was expected to boil at body temperature.

The Reactions and Performance of Pilots Following Rapid Decompression to 40,000 Feet. G. BENNETT, M.D., British Overseas Airways Corporation, London, England.

Recent papers on the physiological effects of decompression to altitudes of the order of 40,000 feet have shown the necessity for a study of the reactions of pilots to this emergency, where physiological changes reinforce the effect of the warning devices provided. During a number of routine check, test, and training flights, jet aircraft were partially depressurized, without previous warning being given to the pilot under observation. The decompressions were carried out at various stages of flight, both when the pilots' workload was heavy and when it was light. The nature and timing of their reactions, and the total time which elapsed before the initiation of emergency descent, were noted and analyzed. A group of pilot volunteers then underwent decompression in the chamber from 8,000 to 40,000 feet in 3 seconds. In each case this was followed by a defined period of anoxia before the order was given to the pilot to put on his oxygen mask. The subject's ability to carry out piloting duties after this exposure was measured by his performance of a standard descent procedure. The results showed that there was some impairment of intellectual capacity in a significant number of the pilots after only 5 seconds exposure at altitude. The relation of this finding to the observed reaction times to decompression is described.

The Effect of Stress and Anticipation to Stress of Urinary Levels of a Catecholamine Catabolite. 1ST. LT. M. LAWRENCE BERMAN, USAF (MSC), and JULIA A. PETTITT, M.T., (ASCP), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

Quantitative estimation of 3-methoxy-4-hydroxy mandelic acid (MOMA), a major endogenous urinary catabolite of both adrenaline and noradrenaline, was made from urine collected from six healthy highly motivated test pilots, one and three hours after the following stresses: forward acceleration, isolation, heat, simulated altitude of 65,000 feet in an MC-1 partial pressure suit and one hour after subjects were given four hours of psychological tests. The results showed that the excretion of this catabolite was 272 per cent above control levels one hour after acceleration, 173 per cent one hour after the simulated altitude stress, 77 per cent one hour post-isolation and 94 per cent after the psychological tests. No significant change in urinary output was observed after heat stress during which subjects were exposed to a temperature of 130° F for four hours. At one week intervals, nine non-rated members of the Wright Air Development Center Human Centrifuge Panel were exposed to a 12 G forward acceleration profile. Each subject had three centrifuge rides. For seven of these subjects at least one of their rides was an unannounced mock ride. Urinary excretion of MOMA, twenty to thirty minutes after an actual exposure to 12 G was 244 per cent over the one hour pre-acceleration level, and 238 per cent during the same period after a mock centrifuge ride. These results suggest that urinary levels of MOMA may be associated with anticipation to stress rather than the response to stress.

X-Ray Survey for Bone Changes in Low-Pressure Chamber Operators. MAJ. CHARLES A. BERRY, USAF (MC), Aerospace Medicine Div., Office of the Surgeon General, and COL. GERRIT L. HEKHUIS, USAF (MC), USAF School of Aviation Medicine, Brooks AFB, Texas.

It has been known for sometime that caisson workers develop aseptic necrosis of the long bones. Some have postulated that those exposed in low-pressure chambers would not develop such lesions as the pressure change was insufficient. In 1956, however, a U. S. Navy study reported an incidence of bone changes in 17.5 per cent of forty low-pressure chamber operators surveyed by x-ray of the long bones. A study was designed to obtain initial long bone surveys on all USAF chamber operators. These would be used for a follow-up study as well as to test the hypothesis that repeated exposure to altitude in low-pressure chambers would produce bone lesions. Five hundred seventy-nine low-pressure chamber operators had x-rays taken of the long bones and completed a questionnaire concerning their altitude exposure. Two hundred ninety-two operators reported episodes of dysbarism. The results of this study are discussed.

A Correlation of Physiological and Mechanical Testing to Measure Oxygen Breathing System Efficiency. AARON BLOOM, B.S.A.E., Sierra Engineering Company, Sierra Madre, Calif.

High altitude oxygen breathing devices and systems have been used successfully by both military services for considerable time and the incidence of safety appears to be relatively high. However, in examining the methods of testing for qualification and/or certification, there is little in the specifications or the available physiological literature to define the measure of relative efficiency of an oxygen system (mask and regulator inclusive). This paper deals with reporting the results of one proposed method of testing oxygen system efficiency, which is suggested in the latest Federal Aviation Agency regulations. The report embodies the results of tests conducted with a mechanical breathing device, as well as live subjects at altitudes up to 40,000 feet. Two types of systems and two types of breathing masks are analyzed.

Acceleration Shock Experiments Using Live Pigs. F. J. BROCK, McDonnell Aircraft Corporation, St. Louis, Mo.

Acceleration shock experiments were performed on live pigs to determine the usefulness of a proposed Mercury Space Capsule pilot support and energy absorption system. The dynamic response of live test subjects is studied through the application of the principles of theoretical mechanics to an analogous mechanical system and some effects of acceleration shock are predicted. The experimental results measured on the live subject are interpreted in terms of equivalent mechanical system behavior and additional live specimen response characteristics are predicted. Several conclusions based on the experimental data are presented and discussed.

Plasma and Electrolyte Changes Produced by Hypercapnia, Hypocapnia and Hypoxia. E. B. BROWN, JR., Ph.D., University of Minnesota, Minneapolis, Minn.

Experiments were carried out on four groups of mongrel dogs. In the first group (controls) control conditions were maintained for one hour. The second group of dogs breathed 30 per cent carbon dioxide for one hour, the third group was hyperventilated with a positive pressure pump for one hour, and a fourth group breathed a hypoxic (8 per cent O_2) mixture for one hour. Samples of arterial blood and skeletal muscle were taken before and at the end of the one hour experimental period. The animal was killed with an overdose of Pentothal and samples of liver, heart ventricle and auricle were obtained as rapidly as possible. CO_2 content, pH, sodium, potassium, and chloride concentrations were obtained on plasma. The same determinations were run on the skeletal muscle sample with the exception of pH; and sodium, potassium, and chloride determinations were carried out on liver, ventricle, and auricle. The classical blood picture of respiratory acidosis was obtained with one hour of hyperventilation and also with one hour of hypoxia, since ventilation was not controlled in the hypoxic experiments and over-ventilation due to the hypoxic drive of respiration occurred. Similarly the usual picture of severe respiratory acidosis resulted from one hour of breathing 30 per cent CO_2. The most consistent and distinctive change in tissue electrolyte composition was in bicarbonate concentration. Skeletal muscle bicarbonate increased during respiratory acidosis and decreased during alkalosis. It appears that skeletal muscle potassium concentration rises during hypercapnia and falls during hyperventilation. These changes, however, are small. Changes in liver and heart electrolyte concentrations under the experimental conditions described do not appear to be significant.

Controls and Displays for Orbital Vehicles. MAJ. EDWARD L. BROWN, USAF, Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

The human engineering problems of controls and displays for orbital vehicles capable of making soft contacts on other orbiting bodies have been studied by a highly qualified research team and two mockups of

the proposed control-display systems have been completed. The mock-ups demonstrate a very imaginative, yet realistic, approach to the problem. One of the novel features is the use of a "distrol"—a display-control in one unit. The "distrol" was chosen as the best solution to the critical problem of displaying and controlling attitude. It consists of a small airplane inside a clear plastic ball about 4 inches in diameter. To use the device the operator simply exerts pressure on the "distrol" in the direction he wishes the orbital vehicle to move. The mock-ups also make extensive use of electronic computers and cathode ray tubes for providing the operator with the capability of computing solutions to the problems and then seeing what the various solutions would mean to his mission. Many of the astronavigation problems are of sufficient complexity that an electronic computer is the best method of providing the astronaut with the capability of getting the answer within the required time span.

Crew Oxygen Requirements in High Altitude Transport Aircraft. FLT. LT. A. C. BRYAN, SQ. LDR. W. C. LEACH, and WING COMDR. R. A. STUBBS, RCAF Institute of Aviation Medicine, Toronto, Canada.

Legislation on the altitude at which pilots of high altitude transport aircraft need to wear oxygen masks has had little experimental support. Therefore, the ability of subjects to don an oxygen mask and subsequently "fly" a simulator following a rapid decompression to 35,000 feet or 40,000 feet has been compared. Most of the subjects were civil airline pilots and civilian flight test personnel whose ages ranged from twenty-one to fifty-two years. Under the test conditions, one subject out of seven lost consciousness at 40,000 feet. At 35,000 feet forty subjects had no serious difficulty in completing the emergency procedures.

Passenger Emergency Oxygen Bag. FLT. LT. A. C. BRYAN, SQ. LDR. W. C. LEACH, and WING COMDR. R. A. STUBBS, RCAF Institute of Aviation Medicine, Toronto, Canada.

Available quick-donning passenger masks are theoretically efficient but they have to be properly fitted very rapidly to prevent a subsequent impairment of consciousness during which there is a considerable risk of dropping the mask. An alternative method of supplying oxygen through an Over-the-Head Bag is described. Although for a given oxygen flow it is less efficient than a mask, it is easy to don, independent of fit and once on continues to supply oxygen regardless of the state of consciousness of the subject. Its performance during simulated rapid decompression to 40,000 feet and 45,000 feet following the emergency descents is described.

Bioastronautical Research for Project Mercury. COMDR. R. L. BURDICK, MC, USN, and NEAL M. BURNS, Ph.D., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

A description of a working mock-up of the Project Mercury Capsule is given. The facility to be described places the Mercury console, acceleration couch, and astronaut in the same relative positions as would exist in various phases of orbital flight. Through the use of appropriate circuitry and recording instruments the following measurements can be made: 1. time required for the astronaut to perceive a signal and decide on the appropriate mode of response; 2. time required for the astronaut to actuate various controls on the console; and 3. concomitant physiological measurements (EEG, EKG). Furthermore, complete stimulus arrays can be programmed onto the Mercury console, and the subject is tested in the space suit both at sea level pressure and 5 psi. From the records obtained to date, selected material will be released which suggest changes in cockpit layout and pressure suit design.

The Effects of Long Term Confinement on Perception, Personality, and Performance. NEAL M. BURNS, Ph.D., RALPH B. ZIEGLER, M.A., and E. C. GIFFORD, Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Perceptual and personality changes were studied in six men confined in a chamber for eight days. Of those procedures used in selecting subjects, the Rorschach Test, Bender-Gestalt Test, Grace-Arthur Stencil Design Test, Personality Orientation Device, and some incidental measures were readministered at the end of the confinement period. Analyses of test results showed some interesting trends. These trends were related to the personality structure of each man and to the effects of the confinement situation. Adaptation appeared to be easiest for the more stable subjects. In general, perceptions became more realistic, more constricted, and more rigid. Fantasies were frequently concerned with loss of movement. Changes in group dynamics were also noted. Some applications of these results are discussed.

Automatic Methods for the Analysis of Physiological Data. W. J. CARBERY, M.S., C. A. STEINBERG, M.S., W. E. TOLLES, M.S., and A. H. FREIMAN, M.D.,

Airborne Instruments Laboratory, Mineola, N. Y., and Sloane-Kettering Institute, New York, N. Y.

The extent to which useful interaction can be realized between the astronaut and the ground control facility depends to a large extent on the speed with which intelligent decisions can be made concerning the physiologic condition of the astronaut. Gross physiological alterations can be detected by the ground controller without the intervention of special techniques; however, corrective action taken after the detection of such extreme conditions may be too late to be effective. For the detection of early physiological alterations, computers can provide a means whereby incoming physiological data from the astronaut can be rapidly analyzed to provide the ground control medical person with data reduced to a form that can be immediately comprehended and used in decision-making. Recent experience obtained from a project dealing with the use of computers as diagnostic aids has shown how multiple physiological signals from the heart, in particular, can be analyzed in detail by the general purpose computer. A method is presented by which the results of such analysis can be used to determine the probability of a subject being either normal or pathological. The problems of analyzing data collected from clinical surroundings and from space are somewhat analogous and a proposed solution to these problems is discussed.

Effects of G Environments on Psychomotor Abilities. RANDALL M. CHAMBERS, Ph.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The psychomotor abilities of the human pilot were tested in a series of 211 closed loop centrifuge runs in which the primary A_z, $-A_x$, and $+A_x$ G vectors and their combinations were systematically varied so as to produce a series of steady-state G fields. During specific flight co-ordination and tracking maneuvers, psychomotor task difficulty levels and acceleration amplitudes were also varied. Physiological and performance recordings were obtained simultaneously during each run. Piloting opinion regarding sensations and perceptions, breathing and visual symptoms, effects on control motions, and adequacy of restraint systems were also obtained from each pilot. An analysis of the various quantitative recordings resulted in a comparison of the effects of each experimental variable on specific psychomotor and physiological components. Performance tolerance curves were constructed which reflect the deterioration of piloting capabilities as a function of (1) G-vectors and their combinations, (2) acceleration amplitude, and (3) task difficulty.

Human Performance During Adaptation to Stress in the Pensacola "Slow Rotation Room." BRANT CLARK, Ph.D., and CAPT. ASHTON GRAYBIEL, MC, USN, USN School of Aviation Medicine, Pensacola, Fla.

In a previous report the symptoms experienced by human subjects living in a slow rotation room for periods up to two days were briefly summarized. It was pointed out that the significant stimulus was the aperiodic angular accelerations associated with movements of the head out of the plane of the constant rotation. The cardinal subjective symptoms included headache, dizziness, sleepiness, depression, visual illusions, nausea, and vomiting. The cardinal signs were pallor, sweating, difficulty in walking and oliguria. Because these symptoms had their origin in stimulation of the semicircular canals, the term canal sickness was considered to be a useful and proper designation. Adaptation occurred after a period of hours to days, and the symptoms either disappeared or were reduced in severity. Following cessation of rotation, certain after-effects appeared, but these were neither as severe nor as long lasting as the symptoms during rotation. The present report deals with a number of physical, psychological, and psychomotor tasks which these persons carried out before, during, and after rotation. At angular velocities of 5.44 or lower, any initial decrement in performance disappeared in the course of their adaptation to the stress. However, subjects exposed to rotation at 10 rpm were severely handicapped, and over a period of two days, their general fitness declined despite some degree of adaptation. The application of these findings to space medicine is brought out.

Observations of a Human Experiencing 2 G for 24 Hours. CARL C. CLARK, Ph.D., Aviation Medical Acceleration Laboratory, Johnsville, Pa.

A subject rode the Johnsville Navy Human Centrifuge for twenty-four hours at 10 rpm of the 50-foot radius arm, giving a resultant linear acceleration of 2 G perpendicular to the floor of the gondola, which was positioned at an angle of 60° with respect to the centrifuge arm. The subject rode, for the most part, in a reclining chair with a back angle of 45° with respect to the gondola floor. Experiments were made with the rotational illusions generated by head motion while on the turning centrifuge. These illusions had a threshold with a head angular velocity of about 0.06 rad/sec. Head

motions of about ten times this rate were nauseating. The subject stood up and walked a few steps two hours after starting, but had a dimming of the peripheral vision and some nausea when attempting this twelve and twenty-two hours after starting. The subject cooked, ate, slept about five hours (subject's estimate), measured his pulse rate, blood pressure, temperature, and time interval estimation accuracy, and looked for hand writing and speech changes. Abdominal discomfort for the first two hours and a mild frontal headache were relieved by aspirin. Two additional tablets were taken during the run. Sixteen hours after the start, an anesthesia sensation developed in the ring and little fingers of the left hand, and some tingling sensation remained for about two months after the experiment. Water (and milk) input during the experiment was 2250 cc; urine output was 890 cc. During the experiment, the white blood count increased from 11,300 to 22,000 per cubic millimeter. Symphony music when desired provided the subject with what he considered a very important distraction from generalized discomforts, particularly of areas in contact with the chair. A feeling of lightness lasted only about thirty minutes after the centrifuge stopped. An abrupt head motion thirty minutes after the run produced retching, but other recovery seemed uneventful.

Aerospace Nuclear Safety. LT. COL. JOSEPH A. CONNOR, JR., USAF (MC), U. S. Atomic Energy Commission, Germantown, Md.

The responsible use of nuclear energy in space is a point of trust which is dominant in the United States approach to space exploration. It has presented the Atomic Energy Commission with a new dimension for its traditional role in health protection from radiation. Aerospace applications of nuclear energy introduce possible radiation hazard to the earth's atmosphere and oceans, to other solar system bodies, and to areas in space along probable orbit paths. Aside from safety considerations, the AEC also has a responsibility to assure that certain long range scientific studies are not complicated by the introduction of new radioactive materials into outer space or to other solar system bodies. Biomedical analyses and research programs associated with the development, testing, and operational uses of the: 1. nuclear rocket (Rover); 2. nuclear ramjet (Pluto); 3. satellite auxiliary power (SNAP); and 4. the manned nuclear aircraft are discussed. Problems of nuclear containment and release, radiation levels, international implications, and concepts for biomedical policy formulation are presented. The basic conclusion is that the aerospace uses of nuclear energy can be safe.

Space Ecology: I—Design Requirements for Chemical Controls of Sealed Cabin Atmospheres. I. COOPER, PH.D., J. H. MILLER, M.D., E. KONECCI, PH.D., Douglas Aircraft Company, Santa Monica, Cal.

This paper describes the various chemical systems (non-regenerative and regenerative) that have been proposed for operational use in a manned space ecological environment for atmospheric control. It outlines certain design requirements (that is, human factors, safety, reliability, weight, volume) for chemical control of the atmosphere. The study includes a comparison of the individual substances and various combinations of them, listing their suitabilities for various space systems. In addition, an experimental study was undertaken to compare the theoretical capacities of these systems with their actual working capacities. Various oxides, superoxides, peroxides and hydroxides were tested for their CO_2 and H_2O absorption and retention capacities under varying conditions of pressure, flow, humidity and temperature. Engineering and packaging requirements were considered for optimized systems.

The Pathological Changes Produced in Large Primates Exposed to High Positive G While Immersed in a Water Capsule. CAPT. PETER H. CRAIG, USAF (VC), LT. COMDR. KENNETH R. COBURN, MSC, USN, R. F. GRAY, MA, and CAPT. EDW. L. BECKMAN, MC, USN, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The biological changes which resulted when large primates were exposed to high positive G while immersed in a sealed, water-capsule have been evaluated by standard clinical methods and by the use of gross and microscopic pathology techniques. The findings from these studies will be presented.

The Response of Mammalian Gravity Receptors to Sustained Tilt. ROBERT L. CRAMER, PH.D., USAF School of Aviation Medicine, Brooks AFB, Texas.

Data will be presented to illustrate the ability of single cells in the nuclear projections of the gravity receptors in the inner ear to signal sustained tilt. Decerebrate and decerebellate cats will be used. Results will be related to problems of prolonged gravity-free conditions.

Fatfree Body Weight of Swedish Air Force Pilots. WILHELM VON DÖBELN, M.D., Kungliga Gymnastiska Central-institutet, Stockholm, Sweden.

The fatfree body weight (FFW) of the human body can be determined from the result of hydrostatic weighing with an error of ± 2 per cent. In a material of thirty-five male students of physical education with a mean weight of 69.3 kg., the mean FFW was 61.8 kg. and fat weight 7.5 kg. If related to height, FFW is best predicted from the cube of the height, but the standard error of estimate is as high as about 10 per cent. In a study of thirty-two male and female students of physical education, it was found that fatfree body weight could be estimated from height and skeletal diameters of the wrist and of the knee with a standard error of ±4 per cent. In contrast to hydrostatic weighing this anthropometric investigation can easily be performed in general practice. In an anthropometric study of 109 Swedish Air Force pilots the above-mentioned measurements were taken. The mean weight was 70.6 kg., mean FFW 61.7 kg., and fat weight 8.9 kg. Standard deviation of fat weight was ± 4.9 kg. This means that even if individual cases of overweight exist, obesity does not represent a general problem for Swedish Air Force pilots. A comparision in this respect is made with data derived from figures for height and weight of U. S. Air Force personnel.

Investigations into the Significance of Elevated Post Mortem Brain Lactic Acid. CAPT. A. M. DOMINGUEZ, USAF (MSC), MAJ. J. R. HALSTEAD, USAF (VC), CAPT. H. MCMICHAEL, USAF (MC), L. R. GOLDBAUM, Ph.D., H. I. CHINN, Ph.D., and MAJ. F. W. LOVELL, USAF (MC). Armed Forces Institute of Pathology, Washington, D. C.

Incapacitation by hypoxia as a causative factor in aircraft accidents is well known. Currently, the only available biochemical means for detecting ante mortem hypoxia in post mortem tissue is a central nervous system (CNS) lactic acid determination. Previous studies performed in other laboratories demonstrated a correlation existing between ante mortem hypoxia and the elevated post mortem level of CNS lactic acid. However, there are cases in which the known circumstances of the aircraft accident strongly suggest hypoxia as a causative factor and yet the lactic acid levels of the CNS are not significantly altered. The parameters of this biochemical reaction were explored in order to obtain an understanding of the significance of elevated post mortem CNS lactic acid. Male rats weighing approximately 275 to 350 gms. were exposed to acute episodes of hypoxia as well as other physiological conditions. Metabolic alterations in response to reduced oxygen tension and reflecting changes in the post mortem level of CNS lactic acid were examined. The post mortem CNS lactic acid level closely parallels the ante mortem concentration of blood glucose. Production of hyperglycemia by glucose infusion, hypoxia or epinephrine injection all caused a rise in CNS lactic acid. The significance of these findings is discussed, especially their application to the medical investigation of aircraft accidents.

Acute Hypoxia During Rapid Decompression and Emergency Descent in Commercial Aircraft. ROBERT T. DONALDSON, M.D., EARL T. CARTER, M.D., Ph.D., CHARLES E. BILLINGS, JR., M.D., and FRED A. HITCHCOCK, Ph.D., Ohio State University, Columbus, Ohio.

The potential danger of passenger jet aircraft decompressions has not been fully explored. Adequate physiologic measurements of events occurring during such decompression are needed as a foundation for protection of medically unselected commercial jet passengers. Healthy individuals were subjected to decompressions in an altitude chamber. The decompression profile simulated the loss of cabin pressure through a cabin window of the Boeing 707. Measurements of arterial oxygen were performed every 5 to 20 seconds, using a double scale ear oximeter during decompression and simulated emergency descent. Maximum rate descents were employed immediately, and at selected time intervals following decompression, using an emergency descent profile characteristic of this jet aircraft. This profile involved decompression from 8500 to 36,000 feet in approximately 25 seconds followed by a descent requiring about 180 seconds. The oxygen saturation decline following decompression and rise following descent was characterized by a time lag not entirely explained by the lung to ear circulation time. Saturations as low as 52 per cent were obtained in healthy individuals following descent without delay and without supplemental oxygen. The use of a commercial flow oxygen mask was shown to be definitely protective. Optimal oxygen flow rate data were also obtained on a type of mask now used in operational commercial aircraft.

Report of a Case of Decompression Sickness Successfully Treated with Recompression. MAJ. ALONZO M. DONNELL, JR., USAF (MC), Headquarters Tactical Air Command, Langley AFB, Va.

E. B., a thirty-nine-year-old obese Air Force command pilot, experienced severe decompression sickness with neurocirculatory collapse following a routine refresher training course in the altitude chamber. Approximately one hour after completion of a chamber flight to 43,000 feet, the individual developed nausea and vomiting, left hemiplegia, a fall in blood pressure to shock levels, and disorientation. The individual's condition progressively deteriorated. Approximately three hours later, the patient was placed in a recompression chamber at a nearby Naval installation. He was immediately recompressed to six atmospheres and over a period of thirty-eight hours was gradually brought back to one atmosphere of pressure. Approximately two hours after being placed in the recompression chamber, the patient began a steady and progressive return to normal physical and mental status. Upon removal from the recompression chamber, he had no pathological residual other than a questionable positive Oppenheims sign on the left and moderate difficulty with finger to nose reflex. One week later, neurological examination, including electroencephalogram, was normal. A review of the literature indicates that this is the first decompression sickness to be treated by the use of recompression. It is the conclusion of the author that had not recompression been available this case would have definitely resulted in a fatality.

Human Performance under Vibration: Physiological and Psychomotor Reponse of a Vibrating Subject Monitoring a Vibrating Display. SQ. LDR. T. M. FRASER, RCAF, G. N. HOOVER, Ph.D., W. F. ASHE, M.D., Ohio State University, Columbus, Ohio.

Although reports are on record concerning the ability of vibrating human subjects to monitor manually a non-vibrating task, there is a need for more information on the more common practical situation where both the subject and the task display are exposed to the same vibration. To investigate this situation, human subjects were serially exposed on a "shake table" to a spectrum of vibration that combined each of the selected frequencies and amplitudes with each of the three planes of space. Frequencies ranged from 2-12 cps, and amplitudes from 0.06 to 0.25 ins. While under vibration the subjects monitored by a control stick a two dimensional visual display presented on a bank of lights mounted on the table. Error was electronically computed. Statistical analysis demonstrated differences in performance relating to frequency, amplitude, and plane. By exposing subjects under similar conditions of vibration to a non-vibrating display, differences were also observed between performance during which both subject and display were vibrating and performance in which the subject only was vibrating. Physiological responses concurrently investigated included electrocardiography, electromyography, respiration, body damping, and post-vibration blood pressure. Specific physiological changes were observed.

Space Environment Simulation. JOSEPH FREEMAN, Republic Aviation Corporation, Farmingdale, N. Y.

A space environmental chamber is described which is 30 feet x 14 feet in size and is capable of achieving a pressure equivalent altitude of 750,000 feet (8×10^{-8} mm Hg). It represents total space equivalent conditions of vacuum, the common denominator of all space flight. It provides a practical means for studies of man, materials and components in the hostile environment of space. Because of its size, it also enables the testing of complete extra-terrestrial support systems such as high altitude gondolas, lunar houses, space suits, and space vehicles or cockpits. The chamber work projected will cover man's environmental tolerances, psychological and physiological requirements, basic limitations and system-matching characteristics. It will enable the development of basic life-sustaining systems such as atmosphere and temperature control, water recycling, food provisioning and waste disposal. Basic life-science problem areas such as bacteriology, radiation, and protection requirements will be investigated. In addition, design factors associated with materials, structures, sealing materials, fluids, lubricants, electronics and thermodynamics will be studied.

Physiological Effects of Dynamic Exposure to Ram Pressures. SQ. LDR. D. I. FRYER, RAF, Institute of Aviation Medicine, Farnborough, England.

Of the physiological stresses to which the body is subjected during ejection seat escape, drag loads are the least well understood. While the seat is erect, the seat-man combination is slowed by the ram pressure, proportional to the square of the indicated air speed, acting on the front of the body. Wind tunnel and rocket track experiments are difficult and expensive. A new approach has been explored, using relatively low velocities in a dense medium, namely water; ram pressure being related directly to medium density, a water speed of χ knots is equivalent to an airspeed of 28 χ knots. A special seat has been constructed and mounted on the arm of the rotating beam channel at the

Admiralty Research Laboratory at Teddington. A 1500 h.p. motor drives this through a water trough 34 feet wide and 15 feet deep at a speed of 27 feet per second, equivalent to an air speed of 455 knots and a ram pressure of 4.9 pounds per square inch. A subject has been exposed to this and lower speeds with no protection other than breathing gear, arm and leg restraint, without injury. Electrocardiographs taken during such runs have shown evidence of cardiac rotation and intra-oesophageal and intragastric pressures have been recorded. Further trials are anticipated to study loads on the restrained limbs.

Underwater Research to Save Pilots. L. A. FUCHS, and B. S. HUTCHINS, USN Air Development Center, Johnsville, Pa.

Investigations into the problems of pilot escape from ditched aircraft have been carried out by NADC engineers who conducted full-scale aircraft, water-crash tests. The aircraft were instrumented so as to determine the impact loads of water entry, the sink rate, and the attitude of sink of the aircraft. Instrumented dummies were positioned in the pilot seat to determine the accelerations which acted upon the pilot at the time of water entry. Ciné cameras recorded the effects of water entry upon the aircraft and upon the dummy pilot. Cameras were also mounted on the aircraft which recorded the motion of the dummy during the water entry and demonstrated the implosion of the canopy upon the pilot. The results of these tests showed that the sink rates of modern military aircraft greatly exceeded the predicted values. Aircraft which submerged with the canopy closed sank in the tail down attitude. Water flow over the canopy of aircraft sinking in this attitude tended to increase the difficulty of opening the canopy. The canopies of the various aircraft types tested imploded at water depths of 20 to 70 feet within 5 to 20 seconds after the aircraft had submerged. The parameters of a water ditching accident which were found to be significant in terms of pilot survival were (1) water impact forces, (2) the aircraft sink rates, (3) canopy implosion characteristics.

Recent Experiments on Subgravity and Zero-G Stress. SIEGFRIED J. GERATHEWOHL, Ph.D., Army Ballistic Missile Agency, Redstone Arsenal, Ala.

Subgravity and zero-G have long been considered an unfavorable environmental condition. For about one decade, several experimenters in this country and abroad have studied the stress as involved in actual and simulated weightlessness on both animals and man. Since weightlessness actually produces a stressless situation, the immersion method has attracted special attention. In this case, no particular surface area has to carry the weight of the body, and the internal stress forces seem to be minimized. Moreover, the remaining stress within the body is isotropic, if the difference in hydrostatic pressure remains small. All this is true within certain limits for the homogenous and non-sensoric part of the organism. Gravity and acceleration changes directly act upon the specific gravireceptors. Stimulation of the vestibular system by angular acceleration will not occur in flight parabolas and orbits, if the subject is at rest, since the rotation of a vehicle around its y-axis does not produce vestibular Coriolis effects. Only rotations of the unrestrained subjects cause extreme disorientation after a few revolutions which, in fact, border on severe cases of vertigo, at times. However, with a visual frame of reference and experience in unrestrained floating, moving, and performing, the weightless condition does not appear to be a serious obstacle to space flight.

Bio-Electronic Analysis of Performance. HARVEY F. GLASSNER, B.S., and GEORGE A. PETERS, M.S., Douglas Aircraft Company, El Segundo, Calif.

Recent experimental work is described which deals with the methods of recording, analyzing, and interpreting multiple physiologic responses. Emphasis is placed on the possible use of bio-electronically monitored phenomena as a criteria of human performance. Data is presented on the physiological changes which were obtained during the performance of complex psychological tasks. Interesting developments from this research are presented which relate to response variability, performance criteria, bioelectronic indices, and the calibration of human experimental plug-in units. Special emphasis is placed on the implications which relate to the analysis and interpretation of bio-electronic data obtained from experimental air and space vehicles.

Federal Aviation Agency Medical Department. JAMES GODDARD, M.D., Civil Air Surgeon, Federal Aviation Agency, Washington, D. C.

The establishment of the Office of Civil Air Surgeon and its subsequent expansion has facilitated the development of a wide variety of activities and programs. I. REVISION OF CIVIL AIR REGULATIONS. II. PARTICIPATION IN INVESTIGATION OF AIRCRAFT ACCIDENTS. At the request of the CAB and in

cooperation with CAB and FAA accident investigation specialists, the OCAS provides for the investigation of those phases of accidents related to medical factors. III. DEVELOPMENT OF HEALTH MAINTENANCE PROGRAMS. For employes of the FAA, it is our responsibility to provide health maintenance services as defined by P. L. 658, including (1) preemployment physical examinations for selected categories of personnel, (2) periodic physical examinations, (3) on-the-job emergency care, and (4) preventive services as indicated. IV. RESEARCH. The Civil Aeromedical Research Institute has been established at Oklahoma City. To assist in development of reasonable standards, we have a variety of research projects in the clinical field now under way. V. TRAINING PROGRAMS. Special training for Designated Medical Examiners will be provided by our office, beginning in the early fall of 1960. A limited number of residencies in aviation medicine will be provided.

Calorie Neutralization During Thermal Stress. CAPT. JOSEPH GOLD, USAF, (MC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

The prime effect of thermal stress is the absorption of calories which, if allowed to accumulate, results in the progressive deterioration (to the point of total incapacitation) of a subject's ability to perform. Because even a small decrease in the net absorbed calories could be beneficial, it was decided to investigate the possibility of neutralizing some of these absorbed calories by feeding the subject cold fluids. Results indicated that under these conditions, not only did the net absorbed calories decrease, but also the subject's ability to withstand heat was markedly enhanced. Since sometimes the difference between ability and disability to perform in heat is a matter of only several calories, decreasing the net absorbed calories may result in extending the time of usefulness during heat exposure.

The EEG as a Method of Monitoring State of Alertness and the Presence of Hypoxia in Pilots. LT. COMDR. JOHN J. GORDON, MC, USN, Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The electroencephalographic literature reveals the plausibility of monitoring state of alertness and hypoxia in pilots. By use of miniaturized circuitry installed in a pilot's helmet, we have been able to read and telemeter electrical activity of the brain during a variety of mental states. The majority of individuals show typical distinct patterns during eyes open, eyes shut, eyes open sequences as well as during drowsiness, light and deep sleep. High altitude chamber runs on a number of subjects also show fairly typical patterns during various levels of hypoxia. The encephalographic findings under various G loadings on the Aviation Medical Acceleration Laboratory centrifuge will also be discussed.

The Peripheral Vascular Response to Local Cold Injury as Observed in the Rabbit Ear Chamber. ARTHUR W. GOTTMANN, M.D., Arctic Aeromedical Laboratory, Ladd AFB, Alaska.

Continuous observations of the small vessels within the rabbit ear chamber were made during and subsequent to injury by cold. The cold injury was produced by way of a fixed platinum wire conductor within the ear chamber platform. The tissue changes ranged from complete freezing immediately around the platinum wire to no observable changes near the periphery of the ear chamber. The vascular beds over and in the immediate area of the freezing thrombosed completely. Those further away showed early unilateral disruption of endothelial function with subsequent sticking of leukocytes and loss of plasma. Later, some of these thrombosed while others, with reduced lumen size continued to function in a less than normal manner. Vascular changes near the periphery of the stage did not appear significant. The observable changes, as a whole, were not different to any extent from those produced by heat under similar experimental conditions.

The Response of the Human Retinal Vessels to Positive Pressure Breathing. FLT. LT. I. D. GREEN, RAF, SQ. LDR. P. R. WAGNER, RAF, and COMDR. B. F. BURGESS, MC, USN, RAF Institute of Aviation Medicine, Farnborough, England.

An oro-nasal mask is used in one type of positive pressure breathing system employed in the RAF for the short term protection of aircrew to altitudes in excess of 40,000 feet. Oxygen is delivered through the mask to the respiratory tract at pressures of up to 60 mm. Hg.: no counter-pressure is applied to the head in this system. The rise in intra-thoracic pressure so produced is transmitted to the veins elsewhere in the body, and the maximum pressure in the peripheral veins of the head is reached within a few seconds after the onset of pressure breathing. As the intra-ocular pressure depends in part upon the venous pressure it will also rise. If, however, the intra-ocular pressure took appreciably longer to reach the maximum

value than the venous pressure, there would be a period when the vessels within the eye would be unsupported, and if the pressure differential across their walls was sufficient, rupture might occur. In order to assess the response of the retinal vessels to positive pressure breathing, retinal photographs have been taken and the vessels examined. From the results obtained it would seem unlikely that there is a significant rise in the transmural pressure of the larger vessels during positive pressure breathing of up to 60 mm. Hg. through an oro-nasal mask.

Criteria for Design of the Mercury Environmental Control System Method of Operation and Results of Manned System Operation. HERBERT R. GREIDER, and JOHN R. BARTON, McDonnell Aircraft Corporation, St. Louis, Mo.

In designing an environmental control system for a manned space vehicle, one must consider man's total requirements. Factors considered in Mercury system design are such items as total pressure requirements, oxygen partial pressure, oxygen consumption, carbon dioxide production, carbon dioxide absorbers, body heat production, methods of heat loss, drinking water requirement, urine production, toxic substances, nitrogen purging and cabin leakage rate. Man's requirements in the pre-launch and post-landing received due consideration. The system's primary and emergency flight modes are described as well as pre-launch and post-landing cabin conditioning. The results of manned simulated flight under normal and emergency modes are discussed.

Activities of Panel on Psychology. WALTER F. GRETHER, Ph.D., Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

The Panel on Psychology includes the field of Psychiatry, and is concerned with those aspects of Bio-astronautics which involve the behavior and performance of space crews and key ground personnel. More specifically, this panel is responsible for the areas of: 1. Man's Role in Space Operations; 2. Personnel Selection; 3. Training; 4. Human Performance; and 5. Psychological Effects of Space Missions. Three general types of activities have been carried out by this panel. The first of these has been the preparation of review articles in three areas of particular significance for Bio-astronautics. These areas are: 1. Effects of Weightlessness on Performance; 2. Effects of Work-Rest Cycles on Human Performance; and 3. Perceptual and Sensory Problems in Space. A second type of activity has been the conduct of Working Group Conferences, leading to published reports with advice and recommendations in particular problem areas. Such a conference has been held on "Personnel Selection." A second conference has been planned on "Training." A third type of activity has been the preparation of action recommendations to agencies engaged in space flight programs.

Physiological Factors Which Limit the Minimal Utilizable Oxygen for Rats in a Closed Microenvironment. F. G. HALL, Ph.D., Duke University Medical Center, Durham, N. C.

Experimental albino rats of known weight and age have been confined to capsules having approximately eight times the volume of the animal. Various parameters affecting the ability of these animals to utilize oxygen to their viable limit have been studied. These include temperature, carbon dioxide tensions, sex, anesthetization, hemoglobin concentration, carbon monoxide poisoning, acclimatization to simulated altitudes, time of exposure to the microenvironment, etc. The normal rat can utilize oxygen to a lower limit of approximately 30 mm. Hg. partial pressure. Other factors influence this value in varying degrees. At low oxygen partial pressures breathing movements cease before cardiac failure. Resuscitation can usually be accomplished after cessation of breathing, but rarely following cardiac failure.

Activities of the Acceleration Panel. JAMES D. HARDY, Ph.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The Armed Forces National Research Council Committee on Bio-astronautics has established as one of its areas of interest the problems of acceleration stress which may be encountered in space travel. The Acceleration Panel of the Committee was organized "to review and report upon the research and development problems concerned with the biological effects of mechanical forces which may be of interest in the area of bioastronautics." Membership of the Panel includes representatives of all of the centrifuge laboratories of the United States as well as those investigating the effects of weightlessness, impact, angular accelerations, oscillatory and random accelerations and noise. At its first meeting, the Panel made a review of the existing devices in the United States for the study of acceleration and concluded with a preliminary discussion of the needed areas of study in the acceleration field which are considered of especial interest to bioastronautics. A brief presenta-

tion of the Panel's deliberations will be made.

Maintenance of Vigilance During Prolonged Simulated Space Flight. GEORGE T. HAUTY, Ph.D., LT. COL. GEORGE R. STEINKAMP, USAF (MC), MAJ. WILLARD R. HAWKINS, USAF (MC), and CAPT. DANIEL M. KELLER, USAF (MC), USAF School of Aviation Medicine, Brooks AFB, Texas.

Highly selected subjects drawn from specific parent populations of experienced pilots were committed to prolonged maximum effort-minimum support flights in the SAM one-man space cabin simulator. During the latter portion of the flight and coincident with the diurnal period of depressed biologic activity, the work load imposed by the operator system was increased by 91 per cent. The effects are appraised in terms of subjective states of alertness, subjective estimates of proficiency attained, the proficiency actually achieved, and physiological functions. Finally, the behavior of these subjects is compared with that of a comparable group subjected to a constant level of work load.

An Integrated Life Support System for Orbital Flight. ROBERT E. HAYES, Ph.D., COURTNEY A. METZGER, and DONALD A. KEATING, B.M.E., Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

This paper presents the results of experimental work performed at the Aerospace Medical Laboratory by the Engineering and Development Branch. The purpose was to develop a completely integrated life supporting system for man in outer space. The system was transposed from the design board into actuality. It represents a life supporting system capable of performing its function for seven days of orbital flight. Every component for such a system must operate under the influence of "weightlessness." The vehicle can be considered a "nose cone" whose major diameter is seven and one-half feet tapering to a height of nine feet. Within this "cone" are housed the life supporting components for one man, all designed to function during zero-gravity. A unique water recovery unit purifies the astronaut's urine to water while the solid excreta are removed by a waste receptacle. Food is stored in a unique "space refrigerator" and prepared in a "space oven." The eating utensils are also designed for zero-gravity use. The breathing environment utilizes chemicals as a source of oxygen and as contaminant absorbers to provide a closed respiratory cycle. The integrated system utilizes life support items functional in orbital flight as well as vital survival gear necessary to maintain life once the vehicle has returned to earth.

Design Concept of the Bio-Astronautical Research and Test Facility of the Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa. EDWARD L. HAYS, B.S., and CAPT. ROLAND BOSEE, MSC, USN, Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

An altitude chamber originally designed and constructed in 1941 has been modified to provide the Navy with a facility suitable for conducting research and development programs relating to the engineering, physiological, and psychological aspects of long term flight operations such as would be encountered in nuclear propelled aircraft and/or space and orbital flight operations. Design details of the facility are set forth and information is presented concerning closed circuit respiration and environmental control systems that are being installed for investigation. A brief discussion is presented on the capability of the facility for the conduct of extremely long duration studies.

Response of Human Subjects to a Simulated Re-Entry Thermal Profile. E. HENDLER, Ph.D., and L. J. SANTAMARIA, B.S., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Subjects wearing Project Mercury space suits were exposed to thermal and altitude conditions simulating those predicted for the interior of a man-carrying capsule re-entering the earth's atmosphere after orbit. Physiological responses of the subjects to the environmental stress are described and their significance discussed.

Pitfalls in Interpreting Electrocardiographic Changes Occurring While Monitoring Stress Procedures. CAPT. ROLAND G. HISS, USAF (MC), MAJ. GEORGE B. SMITH, USAF (MC), and LAWRENCE E. LAMB, M.D., USAF, School of Aviation Medicine, Brooks AFB, Texas.

As the electrocardiogram finds increasing usage as a monitoring device for human stress tolerance studies, it becomes very important to recognize physiologic electrocardiographic changes to avoid erroneous conclusions as to the severity of the subjects' response. Several prominent but innocuous T-wave changes noted during simple respiratory maneuvers such as hyperventilation and breath-holding are described. The influence of orthostasis on the electrocardiogram

produced marked changes which could easily have been mistaken for evidence of coronary insufficiency; this point was demonstrated on many young subjects. The effect of decreased ambient pressure on the electrocardiogram was studied and found to be insignificant; changes occurring at altitude were shown to be the result of influences which could affect the electrocardiogram in like manner at ground level. It was concluded that baseline physiologic responses should be determined on each individual to be utilized in complex aerospace medical research prior to the actual experimental situation.

The Development of an Auto-Adjusting and Positioning Single Disconnect Upper Torso Restraint Harness for the B-58 Escape Capsule. GALEN A. HOLCOMB, Stanley Aviation Corporation, Denver, Colo.

The requirements for harnessing air crewmen in long range bomber aircraft utilizing escape capsules differ greatly from the requirements of shorter range aircraft using open ejection seats. In long range aircraft, the harness must not introduce excessive fatigue and must not require excessive time to adjust and don. Escape capsules must have superior restraint capabilities since there is no wind blast to assist in distributing the deceleration load on the torso. All of the upper torso deceleration must be restrained by the harness. The harness is engaged by a single connect point. All sizes airmen between 5 percentile and 95 percentile may use the same harness without adjustment. This prevents misadjustment of the harness, which might cause localized loading on torso areas incapable of withstanding these loads. When used in conjunction with the inertia reel, to protect the airman from sudden deceleration of the aircraft, it automatically positions itself on the upper torso. When used as a torso positioning device for escape, in conjunction with the powered portion of the inertia reel it also automatically positions itself on the upper torso. The harness provides superior lateral restraint and together with the lap belt provides approximately 35 per cent more bearing area on the torso than present operational harnesses. Approximately seventy-five operational Air Force crewmen have been classified as to anthropometric types and have demonstrated emergency procedures wearing the harness.

A System for Monitoring and Recording Physiological Variables During Environmental Stresses Encountered in Aero-Space Vehicles and Their Ground Simulation Counterparts. R. E. JENSEN, Ph.D., LT. COMDR. JOHN J. GORDON, MC, USN, W. SIPPLE, and R. D. SQUIRES, M.D., Aviation Medical Acceleration Laboratory, USN Air Development Center, Johnsville, Pa.

The development of a physiological sensor package will be described together with supporting recording and data analysis equipment for the study of changes in physiologically important parameters. A system has been designed for maximum versatility in types of sensors used as well as modes of operation and application. It will operate on both aircraft and ground simulation systems such as the Aviation Medical Acceleration Laboratory centrifuge. The use of the system in the design and development of a variety of sensor systems will be discussed. Results of environmental effects on physiological variables which would be encountered in high performance aircraft and space vehicles will be discussed as studied on centrifuge and low pressure simulation systems. The physiological measurements and parameters studied include electroencephalograms, electrocardiograms, blood pressure, gas analysis, and other cardiovascular and respiratory variables.

Some Experiments on the Relative Effectiveness of Various Types of Accelerations on Motion Sickness. W. H. JOHNSON, Ph.D., and N. B. G. TAYLOR, M.D., Ph.D., Defence Research Medical Laboratories, Toronto, Canada.

The nausea which is readily induced by the motions of vehicles moving by land, sea or air has long defied attempts to clearly understand its precise etiology because of the complex interrelationship and differing importance of linear and angular accelerations and other concomitant factors such as vision. An understanding of these factors has become urgent in relation to space travel because of the complex accelerations to which the travelers will undoubtedly be exposed during rocket flight and in the subsequent artificial gravity situation during orbit. The present status of our knowledge will be reviewed and will be followed by a description of some controlled experiments in which over 600 human subjects have been exposed to various types of simple and compound accelerations in the laboratory.

Plant Growth Under Near-Zero Gravity. S. P. JOHNSON, Ph.D., Boeing Airplane Company, Seattle, Wash.

Closed ecological systems of space vehicles or stations will probably make use of algae or broadleaf plants for food and oxygen production. Apparently, plants in general do not have a special requirement for a gravi-

tational field. The algae are largely oriented by the light source. The broadleaf plant above ground is oriented by light in the blue end of the spectrum. Root systems seem to respond more to oxygen tension and moisture levels in the soil than to gravitational fields. Several cabinets have been designed to study the plant requirements for gravity. Germinating seeds and plants are illuminated with blue, red and white light from below. Results of these experiments are presented. The problem of moisture supply appears to be a major one. A cabinet has been designed to study this problem. Preliminary studies have shown that pressurized aerosol feeding of the root system overcame the problem of supplying moisture to the root system. However, return of the aerosol spray to the system has not been solved.

Prediction of Man's Vision in and from the Mercury Capsule. EDWARD R. JONES, Ph.D., McDonnell Aircraft Corporation, St. Louis, Mo.

The advent of a manned orbital vehicle results in new considerations concerning the astronaut's ability to see adequately in and from the vehicle under a wide variety of environmental conditions. Little specific information exists in an integrated form concerning man's visual capability especially in relation to the Mercury vehicle and its intended mission. This paper describes some of the visual considerations in the design of the Mercury capsule, and then predicts what the occupant might see during a mission in conjunction with systems operation, navigation, and scientific observation. This information has been used during the design of the Mercury capsule to make inside and outside vision compatible under diverse lighting conditions, and to establish the requirements for visual training devices. The predictions of the astronaut's capabilities were based on: 1. Man's visual characteristics including perception, glare, brightness contrast, sensitivity to light, and adaptation; 2. Physical environment in orbit including spectral composition, atmospheric attenuation, visibility of stars, light scatter, and earth-sky discontinuity; and 3. Capsule design and operation including lighting, optical viewing devices, systems operation, and operational concepts. Estimates of anticipated visual capabilities were made for the instrument panels, periscope, and center-line window for both day and night under a variety of cockpit lighting and capsule attitude conditions. Significant factors determining visual capability seems to be adaptation, ratio of interior/exterior ambient illumination, and object/background contrast. Definitive information must be obtained from manned orbital missions where adequate observation and recording is possible.

Tolerance of Pure Oxygen Atmospheres. CAPT. DANIEL M. KELLER, USAF (MC), and JACK H. BATES, Ph.D., USAF School of Aviation Medicine, Brooks AFB, Texas.

In consideration of logistics of space operations, subjects were exposed to atmospheres containing essentially only oxygen, carbon dioxide, and water vapor for periods up to one week. The effects on several physiologic parameters are assessed.

The Role of Cutaneous Receptors in the Control of Sweat Production. D. McK. KERSLAKE, Ph.D., RAF Institute of Aviation Medicine, Farnborough, England.

It has frequently been postulated that afferent impulses from thermal receptors in the skin contribute to the central regulation of sweat production. Much of the support for this belief derives from correlations between the rate of sweat production and various thermal parameters of the body, and such evidence can neither prove nor disprove the existence of these receptors. The crucial experiment requires that the thermal state of an area of skin shall be altered without at the same time altering that of the heat regulating centers. Gross cooling of occluded limbs has given conflicting results and is open to the objections that the stimulus is inappropriate to the normal situation and that reflex vascular changes may be producing an indirect effect. In the experiments to be described, the skin of the front of the trunk was exposed to radiant heat, the intensity of which was varied sinusoidally with periods of 8 to 50 seconds. The sweat production from a small region of the forearm (unexposed to the radiation) was recorded with an infra-red analyzer. The sweat rate was found to follow the variation in intensity of the radiation with a time lag which was too short to permit an explanation based on the resulting changes in blood temperature. Similar results were obtained when the occluded legs were exposed to the radiation.

Physiological Effects of Postural Disorientation by Tilting During Weightlessness. BARRY G. KING, Ph.D., Operations Research Incorporated, Silver Springs, Md.

Decerebrate pigeons are useful experimental preparations for studying both static and dynamic postural reflexes. The principal advantage of the decerebrate is that it is less readily distracted than the normal pigeon and gives clean-cut reflex responses appropriate to the stimulus. When postural orientation in relation to the gravitational

field is disturbed by tilting, the pigeon reacts by a compensatory movement and position so that the head is normally oriented in relation to gravity, regardless of the position of the body. If the head is fixed, compensatory eye movements and positions result. The semicircular canals do not participate in eliciting postural compensatory poses. This presentation reports results of experimental observations on the effects of postural disorientation during short periods of weightlessness. The work has been conducted under a Naval Training Device Center Project, "Weightlessness—Training Requirements and Solutions." Experimental flights in a C-131 airplane have been made possible by the collaboration of the Aero Medical Laboratory at Wright Air Development Center. Advantage was taken of the suitability of the tonic postural reflexes in decerebrate pigeons for study of the functioning of the utricular otolith during weightless flights. Observations were made on normal pigeons and on four decerebrates approximately three weeks following operation. Responses to tilting were noted and were recorded photographically during the control and weightless phases of the flights. These responses are compared and interpreted, and illustrative sequences of the motion picture records presented. Grateful acknowledgment is made to the Crew Stations Section of Wright Field Aerospace Medical Laboratory for wholehearted cooperation and assistance. Special acknowledgment is due Captain James E. Wade, USAF, for his effective collaboration and participation in the experimental observations.

Stable vs. Unstabilized Free Fall from High Altitudes. CAPT. JOSEPH W. KITTINGER, JR., USAF, Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

During November and December of 1959, two parachute jumps were accomplished from 76,000 and 75,000 feet, respectively. The jumps were made from a balloon-supported open gondola over the White Sands Missile Range. Though not planned, the subject did not have any stabilizing device on the first jump. On the second jump the subject was stabilized by means of an experimental multi-stage parachute. The results of the two types of free fall are compared, using the subjective reactions of the subject and film showing gyrations to which the subject was subjected during the two types of free falls.

Oxygen Recovery System for Manned Space Flight. J. J. KONIKOFF, B.S., General Electric Company, Philadelphia, Pa.

Supplying man with his metabolic requirement for oxygen is a problem that requires careful study in any program involving manned space flight. Weight estimates indicate that as flight time increases beyond some break-point, it becomes mandatory to manufacture oxygen in flight rather than use prestored facilities. The major source of oxygen-containing raw materials is man's metabolic waste products, CO_2 and water. By collecting these materials on regenerative desiccants, a twofold result is obtained, the vehicle's atmosphere is maintained at safe levels and the H_2O and CO_2 are made available for processing. The extraction of O_2 from H_2O is straightforward whereas the reduction of CO_2 to O_2 directly is difficult and requires a large energy input. However, by converting the CO_2 into H_2O, and then electrolyzing the water to obtain O_2, a relatively simple approach may be applied. The methanation reaction, wherein H_2 and CO_2 are catalytically combined to produce methane and water has been investigated experimentally and found suitable for this purpose. The electrolysis is accomplished in a specially designed cell which normally operates as a hydrogen-oxygen fuel cell. By reversing the cycle, water is electrolyzed. The hydrogen for the methanation reaction is obtained from the electrolyzed water. In this manner, all of man's oxygen requirement can be recovered. Total energy input is relatively low, approximately 5.0 KWH and an estimate of the overall weight of the system indicates the desirability of switching to this regenerative system after a flight time of twenty man-days.

Clinical Otosclerosis — Management in Pilots. C. M. Kos, M.D., University Hospitals, Iowa City, Iowa.

Otosclerosis is a common cause of hearing impairment in young adults. Its insidiously progressive nature eludes detection during its early stages unless hearing is periodically monitored by audiometry. The mechanical portion of the hearing impairment may be corrected in most cases by modern microsurgical techniques. Whether rehabilitation by such methods alters or hinders the individual's ability to meet all requirements for flying duty is unknown, but the possibilities are discussed. In view of the recent success of stapes substitution techniques it is anticipated that the fenestration operation and mobilization procedures will soon be abandoned.

The Ballistocardiographic and Plethysmographic Response to Nitroglycerin in Patients with Coronary Artery Disease.

LOUIS R. KRASNO, M.D., Director Clinical Research, United Air Lines, San Francisco, Calif., and GEORGE J. KIDERA, M.D., Medical Director, United Air Lines, Chicago, Ill.

Preliminary observations indicate a characteristic ballistocardiographic and plethysmographic response to nitroglycerin in patients with coronary artery disease. This response appears to be a "reversal" from that obtained in the normal individual. Most patients with previous myocardial infarction or angina pectoris show an immediate increase or "fixation" in one or more of the displacement, velocity and acceleration components of the ballistocardiogram following the administration of nitroglycerin. The ballistocardiogram in the normal individual indicates an opposite effect and shows an immediate decrement subsequent to the administration of nitroglycerin. It has been further noted that a small number of otherwise healthy young men with family histories of coronary artery disease, demonstrate an abnormal BRN (ballistocardiographic response to nitroglycerin). Inasmuch as the "abnormal normal" individuals may be re-examined periodically for many years, it will be possible to ascertain whether the initial "abnormal" BRN was indicative of subclinical or potential coronary heart disease. The plethysmographic response to nitroglycerin in patients with coronary artery disease also appears to be typical. In these patients the quantitative and qualitative alterations in the ascending limb and the dicrotic notch of the pulse pressure wave are relatively small compared to the response in the normal individual. However, in certain patients with angina pectoris, the PRN (Plethysmographic Response to Nitroglycerin) may be normal. At the present time there appears to be no high degree of correlation between the abnormal BRN and PRN and hypercholesterolemia. This study will be continued over a number of years in order to establish the following objectives: (1) The reliability and validity of the BRN and PRN in detecting subclinical or potential coronary artery disease. (2) The value of the BRN and PRN in evaluating equivocal clinical and electrocardiographic evidence of coronary artery disease, (3) To establish the physiological mechanism underlying the "normal" and "abnormal" BRN and PRN, (4) To determine whether the abnormal response can be interpreted quantitatively so as to correlate the degree of pathology involved, (5) To determine the degree of correlation between abnormal blood lipids and the abnormal BRN and PRN, and (6) To determine the degree of positive family history and abnormal BRN and PRN.

Evaluation of a Simple Coriolis Test for Vestibular Sensitivity. COL. RALPH N. KRAUS, USAF (MC), USAF School of Aviation Medicine, Brooks AFB, Texas.

The duration of the primary turning sensation resulting from voluntarily induced Coriolis stimulation was measured in highly qualified pilots and in controls in the same age group. The stimulation was presented repetitively, and changes in the duration were noted. Theoretical and practical implications will be considered.

Cardiology in the Examination of Civil Air Crewmen. LAWRENCE E. LAMB, M.D., USAF, School of Aviation Medicine, Brooks AFB, Texas.

This presentation will deal with four of the major cardiovascular problems confronting the physician during examination of air crewmen; syncope, coronary artery disease, hypertension and rheumatic heart disease. Loss of consciousness is a frequent occurrence in normal healthy individuals when exposed to excessive stress or unusual circumstances. In a smaller number of individuals it is suggestive of significant disease. Comments relative to the present state of the art in separating these two groups will be discussed. A second major problem is the presence or absence of significant coronary artery disease. Even in individuals in their early thirties, a large portion of them have anatomical changes in the coronary arteries. When these changes become significant in aviation is difficult to ascertain, since clinical diagnosis is somewhat limited with current tools. The history and the electrocardiogram are helpful when utilized properly. Other than these two measurements, there is considerable skepticism concerning the validity of other diagnostic procedures. Problems referable to diagnosis and assessment of its relationship to flight will be briefly discussed. A third problem is hypertension. The approach to diagnosis and its relationship to flight as well as the problem of therapy will be discussed. A fourth problem is the question of rheumatic heart disease or evidence of valvular damage. How does the examiner evaluate the apical systolic murmurs and what does one do about the person with valvular heart disease? When is this sufficiently important to contraindicate continued flying performance? What therapy, if any, should be utilized under these circumstances?

Summary of Electrocardiographic Abnormalities Found in Air Force Flying Population. LAWRENCE E. LAMB, M.D., and KEITH H. AVERILL, M.D., USAF, School of Aviation Medicine, Brooks AFB, Texas.

An analysis of 67,375 electrocardiograms from the USAF flying population provided factual information relative to the true incidence and significance of Right Bundle Branch Block, Left Bundle Branch Block, Wolff-Parkinson-White Syndrome, A-V block, supraventricular and ventricular arrhythmias, T-wave changes and many other electrocardiographic findings. These studies will be summarized.

Education and Training in Civil Aviation Medicine. BRUCE V. LEAMER, M.D., and SHERWIN MILLER, M.D., University of California Medical School, Los Angeles, Calif.

Modern medical education is one of the most complex fields of study in the professional disciplines. The young man planning to go into the practice of medicine looks forward to at least three years of pre-medical education, four years in medical school, one year of internship, and from one to four years in residency training. If he graduates from high school at eighteen he will be at least twenty-seven years old before he can start practicing. If he takes a full residency and fulfills his military service requirements he will be thirty-two years of age. The physician who plans on being board qualified in aviation medicine must look forward to the same lengthy preparations. On the other hand, the engineer, the physicist, the educator and members of many other professions are ready to work from the age of twenty-four years on. We are facing a crisis in our scientific fields today. We are losing ground to Soviet scientific training. In spite of the emphasis placed on educating our young people, we must not forget our civil aviation examiners, the physicians who do the bulk of the examinations of pilots and air crews in commercial aviation. We must offer refresher courses and seminars in civilian aviation medicine. We must urge participation in these courses by F.A.A. examiners. We should ask F.A.A., C.A.M.A., and A.S.M.A. to sponsor these courses. Such sponsorship and cooperation will result in an educational program for the physician in civilian aviation medicine equaled by none. These physicians will in turn stimulate the interest of our youth in aviation and in space science. Lastly, with the advent of an accelerated growth of knowledge in space medicine, it can be anticipated that this frontier of today will give birth to one of the most important and vital disciplines of tomorrow. Thus, we must plan today on methods for meeting this eminent educational, political, and military challenge.

Null-Gravity Simulation. R. B. LEVINE, Ph.D., Lockheed Aircraft Corporation, Marietta, Ga.

In a true state of free-fall, cancellation of gravitational and inertial fields results in no tendency for a body to accelerate with respect to its surroundings and in no tendency for the components of the body to accelerate with respect to each other. Although it is not possible to attain such a state in a laboratory at rest with respect to the earth, it is possible to duplicate the effects of weightlessness to varying degrees, and for extended time spans, on a large number of the body functions and sense organs. Success of such simulation depends especially on nullification of visual, mechanoreceptor, and vestibular cues to the gravitational vertical, and also on substantial reduction of any work required of the organism by virtue of its being in an uncompensated gravitational field. An artificial environment for the simulation of the null-gravity state, based on the concept of Muller (*Science* 128:772, 1958), will be discussed; and a comparison of the physiological and psychological effects of such a simulator with corresponding effects to be expected in true null gravity will be made for several of the important body senses and functions.

The Measurement of Cardiac Output During Headward Acceleration Using the Dye-Dilution Technique. CAPT. EVAN F. LINDBERG, USAF (MC), WILLIAM F. SUTTERER, M.D., HIRAM W. MARSHALL, M.D., CAPT. ROBERT N. HEADLEY, USAF (MC), and EARL H. WOOD, M.D., Mayo Clinic and Mayo Foundation, Rochester, Minn.

The cardiac outputs of six trained centrifuge subjects in the seated position were determined twenty-seven times at 1 G and at interspersed intervals during seventeen, twenty-two and twelve one-minute exposures to 2, 3 and 4 G headward accelerations, respectively, by means of the Mayo Clinic centrifuge. After accelerating to 1.5 G, a 2 G per second rate of onset was achieved. Twenty seconds after reaching the desired level of acceleration, a "slug" injection of cardio-green dye was made into the right atrium via a No. 5 Lehman catheter which was advanced into the heart from the left arm after percutaneous puncture of an antecubital vein. A continuous record of the concentration of dye in systemic arterial blood was obtained by a cuvette oximeter attached to a needle in the radial artery and cardiac outputs were calculated (method of Stewart and Hamilton). A radiopaque catheter was inserted through the bronchial artery via a 19-T-gauge needle to a point near the aortic arch. Both radial

and atrial pressures were recorded continuously except during injection of dye or sampling. The electrocardiogram, respiratory rate, ear opacity, ear opacity pulse, esophageal pressure and reaction times to central and peripheral light signals also were recorded. Results indicate wide variations and inconsistent changes in cardiac outputs. The average per cent change from 1 G control values, measured before and after the acceleration determination with the anti-G suit uninflated, did not show systematic change (range +21 to —25 per cent) 20 to 35 seconds after onset of an exposure to 2 G; 19 (—9 to —28) and 25 (—4 to —25) per cent decreases were found at similar periods after onset of exposures to 3 G and 4 G, respectively. Inflation of a G-4A anti-G suit to 200 mm. of mercury increased the range of alterations in cardiac output but did not significantly change the afore-mentioned average figures.

The Influence of Biological Variability upon Life Support System Design. ROBERT G. LINDBERG, Ph.D., Astro Systems and Research Laboratories, NORAIR, Hawthorne, Calif.

A significant difference in the precision of numerical values exists between physical and physiological data. Documentation will be presented to show the range of representative physiological responses from which "standard" values are derived, the factors which can influence the values, and the difficulties associated with inter-specific data extrapolation. Engineering compromises must be made but man in space is useful only so long as he can efficiently accomplish his assignment. Design criteria derived from average physiological requirements, therefore, appear neither realistic nor economical. With the need for "over-design" of life support systems established attention is directed toward two physiological stresses particular to space flight for which standard biological responses have not been established. These are ionizing radiation in space and altered gravitational fields. A brief review of published data concerning these two stresses supports the contention of a great need for fundamental biological space research in space parametric to the present man in space programs.

Human Factor Responses During Ground Impact. SM/SGT. RICHARD F. MANAGAN, USAF, JAMES W. BRINKLEY, B.S.I.D., S/SGT. GEORGE LOKATOS, USAF, CAPT. ROBERT N. HEADLEY, USAF (MC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

This research effort was undertaken to establish human factor and design parameters of restraint systems and impact attenuators for future manned space flight. The Inclined Test Facility at the Wright Air Development Center is presently being used to simulate vertical impact conditions as experienced in the soft landing of aerospace vehicles. (Soft landing velocities do not exceed 45 ft./sec.) The facility has a capability for simulating soft landings utilizing vehicles weighing up to 30,000 pounds at velocities up to 45 ft./sec. vertical and 60 ft./sec. horizontal velocities. Data gathering techniques have consisted of: oscillograph recordings from accelerometers mounted within the vehicle and on the subject, high speed motion picture coverage, electrocardiogram prior to, during and immediately following impact, a complete physical examination preceding and following each experiment, and accessory laboratory analysis. Vertical accelerations up to 38 G's at the rate of onset of 12,000 G/sec. and duration of .003 sec. have been recorded from accelerometers mounted on the human subjects. To date, a total of thirty-six experiments have been conducted with human subjects. These experiments have been supplemented by a series of twenty-eight control tests utilizing fully articulated anthropomorphic dummies. Information gained from this research effort will be applied to all future restraint and impact attenuator requirements for manned aerospace vehicles.

Closed Circuit Respiration and Environmental Control Systems. DINO A. MANCINELLI, B.S., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

Recent experiences in the investigation of closed circuit respiration and environmental control systems are described. Data are presented on the performance of an experimental closed circuit system wherein potassium superoxide was used as the life support and environmental control element for six men for a period of eight days. Information concerning other physico-chemical closed circuit life support systems currently being installed in the Air Crew Equipment Laboratory Bio-astronautical Research and Test Facility is set forth.

Human Factors Program in B-52G Operations. COL. VANCE H. MARCHBANKS, JR., USAF (MC), Loring AFB, Me.

This includes a report on the "Human Factors Program in B-52G Operations." A brief description is given of the aircraft, duties of the crew, and the preparation and time required for an average mission. Crew

activity inflight is described. Special emphasis is placed on factors which alter crew productivity to include fatigue, inflight feeding, personal equipment and crew rest. Prophylaxis against fatigue through physical fitness is emphasized.

A Method for the Quantitative Determination of Gaseous Tissue Nitrogen. S. F. MAROTTA, Ph.D., E. F. ROBBINS, B.A., and J. P. MARBARGER, Ph.D., University of Illinois, Chicago.

Although it is generally believed that aviator's bends are caused by a release of gaseous nitrogen which was dissolved in tissue and its surrounding fluids, few attempts have been made to quantitate this exchange of nitrogen. A method for the quantitative determination of tissue gaseous nitrogen has been developed and validated. Essentially it consists of releasing gaseous nitrogen from tissue with increasing temperature in a closed system during homogenization in water. A known quantity of pure oxygen is placed over the water into which the released nitrogen is diluted. A gas analysis of the diluted oxygen reveals the quantity of nitrogen released by the tissue as well as the water. With appropriate corrections for water-nitrogen, and other impurities in the oxygen, nitrogen values corrected to STP are obtained. Basic values for various tissues obtained at ground level will be presented and will be used in the future for comparison of tissue nitrogen levels of animals exposed to both increased and decreased atmospheric pressures.

Application of Advanced Engineering Development to Medical Use. ALFRED M. MAYO, Douglas Aircraft Company, El Segundo, Calif.

Many recent engineering developments in the areas of microcircuitry, data analysis and computing techniques are directly applicable to a number of medical problem areas. The techniques utilized in military weapons systems for the detection, identification and classification of military targets can be successfully utilized to aid the physician in the diagnosing of medical disorders. Revolutionary techniques of circuit design and packaging can provide lightweight sensing, measuring, timing, amplifying and transmitting devices of very small volumes. This paper describes some of the recent engineering breakthroughs in the techniques and methodology of component design and system analysis and discusses the applications to the medical field.

A Closed Environmental System Simulator for Manned Space Flight. J. A. MCCAFFREY, B.S., and J. A. STERN, Ph.D., Boeing Airplane Company, Seattle, Wash.

The design and characteristics of the Boeing concept of a space cabin simulator are presented. The design incorporates the results of research on components into biologically self-contained, closed life support system. The simulator, capable of supporting four men for ninety days, is designed to be compatible with the engineering requirements of a realistic space vehicle and mission. Such a device would serve not only to demonstrate the engineering feasibility of a particular ecological system, but also as an engineering development test-bed for improvements in ecological components. It would be used, as well, for the indocotrination, testing and training of personnel for certain aspects of space operations.

An Approach to the Advance Prediction of Tolerance to Acute Physical Stress. CAPT. TERENCE F. MCGUIRE, USAF (MC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

A three phase approach to stress tolerance testing, evolved in 1957-58, is outlined. Phase one involves the physical and psychological screening of candidates. Requirements unique to this type of examination, as opposed to the routine flying physical are discussed. Phase two contains three groups of tests, which form the actual core of this experimental approach. The group one tests of phase two are meant to evaluate certain pertinent physical characteristics of the non-stressed human system in a neutral environment, to assess some of the basic physical equipment the subject possesses. Measurement of physical fitness, blood volume, body density, et cetera, are included in group one. The group two tests measure response to situations that are physically uncomfortable but not physically threatening. Insight into central autonomic and emotional responses are gained by group two. The group three tests involve experimental situations which are not only physically very uncomfortable but are also interpreted as being physically hostile by those tested. There is a wide variation in time duration in this group. Gross emotional and physiological response patterns become evident in group three. Phase three involves cerebrative and coordinative functions. Baselines of performance are obtained in the non-stressed state and the tests are later repeated under physical stress to evaluate the performance decriment, which varies appreciably among individuals. The importance of a repetition of certain selected tests in phase two is

stressed, since there are different emotional correlates to first and subsequent exposures and since the emotional substrate affects physiologic patterns. The results of the testing are placed on a simple graphed summary sheet which lends itself to ready comparison of individuals. Examples of test results are presented.

Venous Plasma Levels of Catechol Amines in Response to Several Physical Stresses. JOHN P. MEEHAN, M.D., University of Southern California, Los Angeles, Calif.

Measurements of the venous plasma levels of adrenalin and noradrenalin in four physical stresses were undertaken with the premise that changes in the plasma levels of these catechol amines may reflect the extent to which the sympathetic nervous system participates in the observed physiologic adjustments. The fluorometric method of Weil-Malherbe and Bone was used for the plasma catechol amine assays. The physical stresses were positive acceleration on the human centrifuge, a modified cold pressor test, whole body cold exposure and exercise. Severe exercise of short duration produced at least two-fold increases in the plasma concentration of noradrenalin over control values. The adrenalin response was not consistent although averaged data showed an increase in adrenalin plasma levels after exercise. The cold pressor test and whole body cold exposure failed to show alterations in the plasma catechol amine levels that could be associated with the physiologic responses to these stresses. Exposure to positive accelerations of up to 3.5 G for as long as ten minutes produced no consistent changes in either the noradrenalin or adrenalin plasma levels. Longer exposures to accelerations near the blackout threshold produced marked increases in the plasma noradrenalin in some subjects. The results of these investigations indicate that venous plasma levels of the catechol amines are altered appreciably only in situations where there is a severe physiologic stress involving general sympathetic stimulation of the cardiovascular system.

Emergency Escape Capsule System. 1ST LT. WILLIAM F. MICKELSON, USAF, Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

With the advent of manned supersonic air weapon systems it was apparent that open ejection seat systems could not afford the aircrew member sufficient protection from increased windblast on ejection and exposure to the elements during descent. This resulted in a requirement for an emergency escape capsule. The emergency escape capsules now in the developmental stages consist of canopy capsules, nose breakaway capsule, individual crew capsules and other capsule designs. The testing programs conducted by the Aerospace Medical Laboratory and the individual contractors consist of the following: (1) Flotation and Survival Tests, (2) Sled Runs, (3) Drop Tests, (4) Stress and Fatigue of Capsule Structures, et cetera. Test data collected relative to human factors consist of: (1) Oxygen Consumption, (2) CO_2 Concentration, (3) Subject comfort index, (4) Survival equipment available, (5) Trend analysis from graphic presentation of known parameters, (6) Tolerance of human in relation to deceleration forces, restraint harness requirements, (7) Tolerance to temperature and pressure. The emergency escape capsule design is constantly under evaluation by the Aerospace Medical Laboratory to study human factors with relation to the escape capsule concept.

Oxygen Equipment and Use in Private Aircraft. ARTHUR E. MILLER, Scott Aviation Corporation, Lancaster, N. Y.

The historical background of private flying is briefly reviewed, and attention directed to the increase in operational altitudes, flight duration and frequency, number and complexity of instruments and controls, and procedural problems and responsibilities. The economic and technological significance of private aviation is emphasized, and sociological and economic differences between the private flier of today and his earlier counterpart are discussed. In view of the increase in factors conducive to accidents, and the more serious effect of accidents, there is a need for greater safety consciousness and precautionary measures to assure pilot proficiency. Intensive use of oxygen to assure full utilization of pilot capabilities is advocated. Presently used oxygen systems are compared with their predecessors, and the proposed formulation by the Federal Aviation Agency of regulations to cover oxygen equipment in private aircraft is discussed.

Homeostatic Instrumentation for Space Cabins. J. H. MILLER, M.D., I. COOPER, Ph.D., and E. B. KONECCI, Ph.D., Douglas Aircraft Company, Santa Monica, Calif.

Homeostatic instrumentation refers to the necessary devices that will maintain the space cabin environment and the human occupants at an optimal functional state. To achieve and maintain this state, considerable interaction between the human occupants

and the space cabin mechanisms will be necessary. The instrumentation will act as their means of intercommunication; information that will be required of and for man and machine would consist of present state, summary of previous monitoring, predicted state, need for adjustment and need for repair. Items that need be observed and controlled in the environment are: partial pressures of each constituent of the atmosphere, temperatures, leakage, available stores, noxious gases and particulate matter, air movement, radiation, sound and vibration, accelerative forces, and illumination. The quantity of these present may be determined by such devices employing mass spectrometry, thermal conductivity, polorography, infrared absorption, electrical conductivity, mechanical motions, ionization, and photoelectricity. Instrumentation of the human operator would serve to measure psychological functions such as alertness, judgment, and reaction time by sensing his response to specific stimuli and monitor end-expiratory respiratory gases, heart rate, GSR, EMG, occular motions, and/or temperature. Altering signals, modification of the environment, or a programmed override could be used as needed to optimize the operator's functional state.

Human Physiologic Variations Observed During Exposure to Five P.S.I. Pure Oxygen Ambient Pressure. SHERWIN MILLER, M.D., FRANCIS B. QUINN, M.D., and BRUCE LEAMER, M.D., University of California Medical School, Los Angeles, Calif.

A report and discussion of some of the more important physiologic phenomena encountered while monitoring human volunteer subjects exposed to 5 p.s.i. pure oxygen pressure in the Litton Industries high vacuum chamber space suits. Increased insensible water loss through the lungs and skin was measured and amounted to 800 cc.'s per hour. A state of general malaise and fatigue has been noted after variable periods of time (usually within two hours) and in some cases has significantly impaired performance. Electrocardiographic changes consisting of S.T. & T. wave variations resembling abnormal patterns were noted and as yet have not been fully explained. This presentation will consider the above observations in terms of their possible etiologies. In addition, if 5 p.s.i. is to be emphasized for a space cabin atmosphere, then it is herein postulated that the above variations necessitate a serious consideration of the potential problems they impose on both man and his life support system. Methods wherein such problems can be averted will be discussed.

Terella Toxicology. ORVAL H. MINNEY, North American Aviation, Downey, Calif.

A discussion is presented of various toxicity problems to be considered in the design of a manned space capsule. Toxicity is considered for materials which might be deleterious to health, normal longevity, and reproduction, even though signs or symptoms may not be evident immediately after successful completion of the mission. The special factors which will modify the earth-based notions of toxicity are presented. It is possible that substances may be neglected which would under these special circumstances cause unforeseen trouble. It is the purpose of this paper to attempt to foresee the unusual, unexpected toxicity problems, as well as the classical problems in an unclassical setting. Consideration is given to the instrumentation necessary to measure the contamination levels, the elimination of sources of contamination, control of the atmosphere and the effects on the space pilot and his necessary adaptions.

Orthopedic Injuries Common to Airport Operations. JULIUS S. NEVIASER, M.D., Washington, D. C.

This paper will cover an analysis of the orthopedic patients seen at the Washington National Airport from the years of 1952 to 1959, a period of eight years. The group of cases under discussion will comprise those of the civil air crewmen as well as the operational personnel. The employee most frequently seen and treated was the mechanic. The number of mechanics examined were 95 out of a total of 202 patients, making a percentage of 47 per cent. Only three pilots were seen and this may be attributed to the fact that they had stricter medical supervision and their duties did not expose them to the hazards of occupational trauma that mechanics encounter in their daily work. Comment will be made of the effect of the high speed aircraft on cabin attendant orthopedic injuries. The common injury sustained was a low back strain, most of which responded quite well under conservative measures. Next in frequency were knee injuries and various types of fractures which were just about equally divided. Twenty cases of external epicondylitis of the eblow were treated and thirteen of this group were in mechanics. In addition to the outline of the type of injuries encountered, the causes of them will be discussed followed by the methods of treatment used. Suggestions for the prevention of some of these conditions will be made. By close cooperation of the medical staff involved in the care of these cases only twenty-nine patients were operated upon, this being 14.4 per cent of the total number seen and treated.

Observations on Damage to Experimental Animals Exposed to Mechanical Vibration. R. W. PAPE, and D. E. GOLDMAN, Naval Medical Research Institute, Bethesda, Md.

Anesthetized male cats have been exposed to mechanical vibration in the range from 5 to 20 cps. Pulmonary hemorrhage and evidence of traumatic myocardial damage may occur if the acceleration exceeds about 5 G for a sufficient time. Both the frequency and severity of the injuries increase as the acceleration increases. When the acceleration exceeds about 10 G, death may result from the exposure. Minimal injury is indicated by delayed changes in cardiac potentials, which may, however, be reversible. Confirmatory evidence is obtained from post mortem and histological examination of tissues. Other observations have revealed a definite effect of the method of supporting the animals during exposure.

The "What" and "Why" of the New Regulations. CAPT. PHILIP B. PHILLIPS, MC, USN, USN School of Aviation Medicine, Pensacola, Fla.

An appraisal of the new FAA regulations relating to psychiatric and personality disorders is discussed with an attempt to evaluate the reasons for the changes. The viewpoint will be that of the examiner who is appraising the civil air crewman. The necessity for the physician being comprehensive, factual, and reasonably positive in his evaluation will be emphasized.

Requirements for the Design of an Operational Closed Ecological System. WESLEY O. PIPES, JR., Ph.D., Northwestern University, Evanston, Ill.

There are many approaches available for the theoretical consideration of a closed ecological system. However, since the field of reference for these particular activities is Bioastronautics the approach selected was to consider man as the essential element of the system, to attempt to characterize man as a component of a closed ecological system, and to select the other components to fit human requirements. It is recognized that the present state-of-the-art is such that it will take a great deal of time and effort to provide the information required for the design of an operational closed ecological system. In the meantime, explorations outside of the terrestrial ecosphere will have to depend upon support systems having definitely limited operational periods. Much of the information gained from the operation of support systems will be valuable in the design of a completely closed system. On the other hand, if a concerted effort to develop a completely closed system is not undertaken at present, the realization of a system suitable for long term exploration will be delayed beyond the time when it is required. The attempt to characterize man as an ecosystem component is being directed along the following lines: 1. A quantitative description of human metabolism in terms of thermal balance, water balance, respiratory quotient, et cetera; 2. a characterization of human atmospheric requirements; 3. a tabulation of the known and suspected human nutritional requirements; 4. a description of the types and amounts of human waste products; and 5. a review of human toxicology. A study is also being made of the devices and processes which might be employed as components of a closed ecosystem containing man. These components have been classified as to their use in gas purification, water recovery, waste disposal, and food production.

USAF Emergency Escape Experience 1949-1959. COL. KENNETH E. PLETCHER, USAF (MC), and MAJ. SAMUEL E. NEELY, USAF (MC), Norton AFB, Calif.

This paper will cover USAF ejection and bailout experience for the past ten years from the following aspects: 1. The significance of escape. Ejection fatalities are significant part of aircraft accident losses; 2. The reasons for escape. Escape is precipitated by a variety of circumstances; 3. The results of escape efforts. A summary of escape success with definition; 4. The role of various factors in escape; (a) Altitude—low altitude is still the problem, (b) Airspeed—although hazardous has not been serious, (c) Equipment—there is still need for improved equipment, (d) Post-ejection survival—much equipment carried is seldom used. Water survival is greatest actual hazard. 5. The reasons for failure to escape. The incidence and causes of failure in spite of opportunity and adequate reason; 6. Improved escape potential. Seat separation device and rocket catapult.

Renal Responses to Heat and Altitude. RITA M. RAPP, M.S., CAPT. LEO A. WHITEHAIR, USAF (VC), and CAPT. NEVILLE P. CLARKE, USAF (VC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

This is a preliminary report on renal excretory responses as affected by increased environmental temperature, clothing and altitude. Eight healthy male subjects, dressed in a non-pressurized and unventilated partial pressure suit, were exposed to 3 thermal stress levels (80°, 100°, and 120° F) for a period of four hours at a simulated altitude

of 25,000 feet. The altitude chamber was ventilated. Control determinations were made in light clothing at ground level pressure with an 80° F ambient temperature. Subjects maintained a control diet, with *ad lib* water intake, for approximately twenty-four hours before and after the stress period. The subjects were allowed to continue with their usual daily tasks before and after the stress period. Samples of voided urine were collected, measured and analyzed for sodium, potassium and osmotic concentrations. Periodic blood samples were also analyzed. Pulse rate, rectal temperature and body weight were recorded throughout these experiments. Experimental results from the thermal-altitude stress have been compared to ground level control data. Serum electrolytes showed no significant changes from control values. The pattern of electrolyte excretion showed moderate deviation from the control during the 80° and 100° F experiments, with maximum effects occurring during the last two hours of exposure. Urine volume increased in the first two hours and decreased the last two hours. Na^+, K^+ and osmotic concentrations showed reductions with a return to control levels in the recovery period. Mean body weight loss per 1.73 m^2 was 1.07Kg and 1.58Kg, respectively. At 120° F there was a marked decrease in urine volume, Na^+, K^+ and osmotic concentrations. The values remained lower than control levels during the recovery period. The mean body weight loss at 120° F exposure amounted to 2.42 Kg/1.73 m^2.

Pathologic Findings in Three Cases of Decompression Sickness. CAPT. R. R. ROBIE, USAF (MC), MAJ. F. W. LOVELL, USAF (MC), COL. F. M. TOWNSEND, USAF (MC), Armed Forces Institute of Pathology, Washington, D. C.

Three fatal cases of possible decompression sickness are reviewed. These heretofore unpublished cases were found in the routine processing of aircraft accident fatalities in the Aerospace Branch of the AFIP. This entity is poorly understood and reported cases of fatal outcomes are rare either because of the nature of the disease or because it has gone unrecognized. These cases illustrate the wide variation in altitude exposure, symptomatology, survival time and pathologic findings found in this condition. Primary emphasis is placed on the pathologic findings and the problems of making a definitive diagnosis.

Cardiovascular Disease and Air Travel. COMDR. N. D. SANBORN, MC, USN, and CAPT. ASHTON GRAYBIEL, MC, USN, School of Aviation Medicine, Pensacola, Fla.

A total of 3717 questionnaires were sent to the membership of the Aerospace Medical Association and of the American College of Cardiology in the attempt to obtain more information concerning cardiovascular disease and its relationship to modern day air travel. The opinions and comments concerning individuals with cardiovascular disease traveling by air were solicited. Also the personal experience with acute cardiovascular incidents occurring in association with and possibly in part or wholly attributed to air travel were requested. The resultant tabulation of the questionnaire will be given. Conditions of modern day air travel and their possible effects on individuals with cardiovascular disease will be briefly covered. Advice and recommendations that might be given to these individuals will also be briefly discussed. It is hoped that any additional information will be helpful to doctors who might be contacted by a patient with cardiovascular disease contemplating travel by air.

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

With the preparatory phase of the Mercury program well under way it seems advisable to identify, among the many problems concerning potential radiation hazards in space flight, those of immediate practical significance and to concentrate the research efforts on their solution. This poses the question what part of the work could be assigned to ground-based studies and what part would demand actual experimentation in space capsules. For the conventional types of radiations in space, such as protons, electrons, and photons, the exposure hazards can be assessed as soon as the energy spectra and intensities involved and their transition effects in organic absorbers are known. Experimentation with biological specimens in space vehicles for this type of exposure seems not justifiable. On the other hand, the microbeam effectiveness of heavy nuclei, narrow meson cones, and disintegragation stars on living matter is at present incompletely understood. In the medium and high dose range, some data are available from ground-based experiments with artificial heavy nuclei (Linear Accelerator) or composite deuteron microbeams (Cyclotron). Yet information on the RBE for low-dosage long-term exposure and on the threshold for local cellular damage from a single event is missing. Special significance rests in this respect on the so-called superheavy nuclei that so far have been recorded only at rare occasions, yet might pose a serious problem when long-term exposures

outside the atmosphere become reality. It seems doubtful that this area can be adequately investigated in ground-based experimentation alone.

Volume Dose and Depth Dose in a Human Target in High Intensity Proton Radiation Fields in Space. HERMANN J. SCHAEFER, Ph.D., USN School of Aviation Medicine, Pensacola, Fla.

Data from missiles, satellites, and deep space probes convey specific information on the intensity and the energy spectrum of the proton beam in the inner Van Allen Belt, permitting concrete estimates of the dosage distribution in a human target. It is shown that this distribution is highly structured for an object the size of the human body and that, as a consequence, body position greatly influences the integral volume dose. Analysis of the effect of shielding reveals that, contrary to common inhomogeneous radiations, the proton beam of the Van Allen Belt continuously hardens with increasing prefiltration up to very heavy shielding. Depth dose charts of representative cases are presented and discussed.

A Concept of Triple Tolerance Limits. KARL E. SCHAEFER, M.D., USN Medical Research Laboratory, New London, Conn.

Utilizing data on chronic CO_2 toxicity the concept of triple tolerance limits to environmental changes is introduced. The following three levels of activity, in regard to tolerance limits, are established: 1. Levels producing performance deterioration, alterations in basic physiological functions as expressed in changes of weight, blood pressure, pulse rate, metabolism and finally pathological changes (3 per cent carbon dioxide and above); 2. Levels at which basic performance and physiological functions are not affected. Under these conditions, however, slow adaptive processes are observed in electrolyte exchange and acid base balance regulations which might induce pathophysiological states on greatly prolonged exposure (1.5 per cent CO_2); 3. Levels at which no significant physiological, psychological and adaptive changes are observed (.5 to 1 per cent CO_2). Data on chronic exposure to altitude appear to support the findings made in chronic CO_2 toxicity studies. The concept of triple tolerance limits allows an approach to studies which should give design engineers more reliable criteria and a better quantitative description of man's characteristics.

Medical Considerations in Civil Jet Operation—Current Trend. OTIS B. SCHREUDER, M.D., Medical Director, Overseas Division, Pan American World Airways, Inc., N. Y.

This paper brings up to date the present-day thinking with regard to the medical considerations and problems in civil jet air transportation. Current civil jet transport operation is briefly described from a historical standpoint with a review of operational statistical data. The need and use of oxygen and oxygen equipment is also briefly reviewed. Current information and data on decompression are revealed. Transition and indoctrination of aircrew members are discussed giving subject matter and problems encountered. Passenger reaction is revealed with particular reference to the reasons for lack of fatigue. Brief statistics on medical emergencies encountered in flight are outlined and the carriage of passenger patients in the jet versus the piston-engined aircraft are also discussed. The potential hazards of ground personnel engaged in jet operations and the precautionary safety measures instituted are set forth.

Space Environment Simulators. OTTO SCHUELLER, Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

A design study of a test facility for reproduction of some hyperenvironments of outer space, the nearer planets, and re-entry conditions is presented. The purpose of this test facility is to assure the suitability of personal protective assemblies such as space suits, capsules, and life support systems by testing in the same extreme environments in which they will be required to perform their mission. It will also serve for selection and training of astronauts, and for research of physiological and ecological problems related to survival outside the earth's atmosphere. A combination of three interconnected chambers is proposed: 1. A high vacuum chamber with black chamber walls cooled by liquid helium, air or nitrogen, for reproduction of lunar night and periods of orbiting in the shade of planets or space stations; 2. A high vacuum chamber with sun radiation simulators and infrared radiators for the reproduction of lunar day, orbiting in sunshine including the neighborhood of Venus, and re-entry conditions; 3. A safety chamber for instantaneous reversal of the test conditions in an emergency case and rescue of the test subject within a few seconds; Recommendations and feasibility considerations regarding construction and operation of space test chambers are included based on experiences of the U. S. Air Force in using altitude chambers for testing of personal protective equipment and for training of Air Force personnel.

Organization and Function of the Armed Forces-NRC Committee on Bioastronautics. SAM F. SEELEY, M.D., Division of Medical Sciences, National Research Council, Washington, D. C.

The Armed Forces-NRC Committee on Bioastronautics was organized in November, 1958. It consists of an executive council, nine scientific panels and a number of members of the committee at large. Membership represents scientists in all major fields in bioastronautics of the Armed Forces, other governmental agencies, universities, and industry. Though constituted primarily to be advisory to the Armed Forces, the Bioastronautics Committee, in keeping with policies of the National Academy of Sciences, National Research Council, is receptive to requests for assistance from any agencies of the government. The relationship of the Bioastronautics Committee with other agencies concerned with all aspects of the effect of the space environment upon biological organisms, including man, is discussed. The committee serves as a forum for the interchange of ideas, an appraisal of the present status of research and the stimulation of research in all biological fields concerned with space.

Recording of Inflight Stress in Jet Fighter Planes. CARL WILHELM SEM-JACOBSEN, EEG Laboratory, Gaustad Sykehus, Oslo, Norway.

We have recently described the selection and classification by airborne electroencephalography of pilots of high performance aircrafts, AEROSPACE MEDICINE, 30:797, 1959. To ascertain the significance of these findings forty more missions have been flown adding flight pattern recording, ECG and inflight movies to the examination. Filmstrips of the pilots' reaction will be presented. The pilots are shown at the time of a stressful turn and, five minutes later, during three bomb-runs at a target range. This is a standard NATO manoeuvre for the F-86. EEG, ECG and flight pattern recording was made from take-off to landing, movies for technical reasons only for brief periods. There had been no question about the fitness of the pilots. Three pilots rated A—with only minimal changes in the airborne EEG test. They appeared unaffected on the movie. One represents the B-group, with short episodes of high voltage delta-theta-activity in the EEG. The movie revealed an eight seconds convulsion. The last pilot represents the C category—showing major EEG abnormalities. The movie revealed him unconscious for thirty seconds. The film underlines the value of airborne EEG testing as an objective method to evaluate the pilots' ability to act and react when subjected to flight stress and fatigue in the high performance aircraft and space vehicles. An unknown number of pilots have convulsions during "black-outs," and brain anoxia also as secondary response in spite of good O_2 supply.

Results of Bioastronautics 1959 Primary Cosmic Radiation Research Program. LT. COL. DAVID G. SIMONS, USAF (MC), USAF School of Aviation Medicine, Brooks AFB, Texas.

Results of Bioastronautics 1959 Primary Cosmic Radiation Research Program. This paper will describe the techniques used for monitoring *Neurospora* experiments exposed on high altitude balloon and rocket flights. It would include monitoring techniques used with tissue culture nerve cell preparations and the results of the observations available.

The Ability of Pilots to Perform a Control Task in Various Sustained Acceleration Fields. CAPT. H. A. SMEDAL, MC, USN, BRENT Y. CREER, and RODNEY C. WINGROVE, Ames Research Center, National Aeronautics and Space Administration, Moffett Field, Calif.

An investigation has been made attempting to establish the ability of pilots to perform a control task in various sustained acceleration fields typical of those which might be encountered by a forward facing pilot flying an entry vehicle. For this program a special restraint system was developed in an attempt to maximize the accelerations in which the pilot could operate. The experiment was accomplished utilizing a flight simulator setup involving a centrifuge. The research program was under the joint sponsorship of the Ames Research Center (NASA) and the AMAL. Naval Air Development Center, Johnsville, Pennsylvania. For the runs, the subject pilots were immersed in a nearly constant, sustained G field while flying a closed loop system with dynamics typical of an entry vehicle. Vehicle pitch and roll attitude and a randomly driven target were displayed to the pilot on a cathode-ray tube. During the tests, pilot performance was determined as a function of his tracking ability. The end conditions on the runs were based on physiological consideration or from a marked deterioration in the pilot's tracking ability. A detailed description of the restraint system will be presented as it relates to protection against the various acceleration vectors. The effects caused by acceleration on the circulatory, respiratory and visual systems will be discussed in relation to the pilot's tracking ability. It is believed that the information which has been obtained will be of con-

siderable value in the design of atmosphere entry vehicles.

Application of Medical Research to Civil Aviation Medicine. J. E. SMITH, M.D., Federal Aviation Agency, Washington, D. C.

In civil aviation medicine, medical research will be directed toward improvement of medical standards and toward application of the most efficient techniques of medicine to the pilot certification program. Methodology for the improvement of diagnostic techniques and for the development of prognostic information related to various disease states is of vital importance. One of the major missions of the Federal Aviation Agency is to promote safety through design, construction, and performance of aircraft. In this respect there are many problems needing research, such as ventilation, temperature and humidity of the air at high altitudes, which must be studied in relation to the effect on the human body. Human factors research involves physiologists, psychologists, biophysicists, with overlapping contributions from the medical sciences. Much of this research will have the function of backing up Agency regulatory material and will embrace such diverse subjects as aging in pilots, spatial orientation and dizziness, working environments of air traffic controllers, cardiovascular research, effects of noise and vibration, as well as studies of escape and survival procedures in the face of emergencies. The Federal Aviation Agency feels that the entire question of mental and physical standards for pilots is open to challenge. It must be determined whether current physical standards are suitable for current operations and whether they are consistent with the knowledge acquired in recent years.

Changing Concepts in Physical Standards. F. S. SPIEGEL, Office of the Surgeon General, Department of the Air Force, Washington, D. C.

Physical standards for flying have not changed significantly in the past decade. There have been refinements in examination techniques and improvements in evaluation of certain organ systems which are now reflected in more thorough testing procedures. The application of physical standards to the stresses or requirements of a particular type of flying duty is undergoing continuous evaluation. Specific standards are being scrutinized and interpreted in somewhat different terms of reference. Man is unchanged but his operational environment has become more and more hostile and unforgiving and his duties more taxing and complex. This paper will touch on some of the basic physical requirements for flying in the United States Air Force, will describe the philosophy of waivers for physical defects, and will relate physical standards and physical requirements to crew selection and space flight.

Hemodynamic Changes During Transverse Acceleration. CAPT. SHELDON H. STEINER, USAF (MC), CAPT. GUSTAVE C. E. MUELLER, USAF (MC), RITA M. RAPP, M.S., CAPT. NEIL S. CHERNIACK, USAF (MC), and JUSTIN L. TAYLOR, JR., Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

The measurement of the cardiac output using a dye-dilution technique has been made in dogs during transverse acceleration stresses of 6, 10 and 14 G for ten minutes at each G level. Arterial samples drawn before and during the stress were analyzed for oxygen saturation. Preliminary observations of data reveal no essential change in cardiac output, and peripheral resistance is maintained without significant changes. At 6 G the oxygen saturation remains within normal limits and at higher G levels there is a progressive diminution of arterial oxygen saturation.

The Pathologist and the Appraisal of Safety Equipment. SQ. LDR. P. J. STEVENS, RAF, RAF Institute of Pathology and Tropical Medicine, Halton, England.

The importance of deduction in the appraisal of unsuccessfully used safety equipment is discussed. It is emphasized that the pathological examination of fatal casualties is an integral part of the investigation of such cases. Illustrations of the use of pathology in the evaluation of simple items of equipment such as seat harnesses and protective helmets are given. The pathological investigation of fatal attempts at escape in flight is outlined and emphasis is laid on the identification of malfunction of equipment at particular stages during ejection escapes. The work of the pathologist in the appraisal of safety equipment is regarded as an important aspect of preventive medicine.

Optimum Theoretical Visual Capabilities of the Human Operator in an Orbital Vehicle. W. F. SWARTZ, B.S., R. W. OBERMAYER, M.S., The Martin Company, Baltimore, Md.

An analytical human engineering evaluation of the man-periscope system method of presenting visual information to the orbital operator is presented. The objective was to

establish the optimum visual performance value of the operator in an orbital vehicle. The evaluation describes the theoretical system performance in engineering terms. Adhering to human engineering evaluation practices, the problem evolved into establishing (1) the type of information and (2) the display principles that influence operator visual performance while executing a military reconnaissance task. It was determined that visual performance could best be described as a function of (1) minimum resolvable object length, (2) area length, (3) time, and (4) scale factor. Review of the available literature disclosed that forty-two parameters effect visual performance. The analyzable parameters were examined as to their interrelationships and their effects upon the dependent variables for five representative altitudes. The derived data were then extrapolated to an examination of the entire practical orbital altitude range of 113 to 22,289 miles. It was found that length of the critical targets must be extremely large for the higher altitude ranges where time and area have optimum value. For lower altitudes, with any type of good resolution, time to view and area scanned are not within acceptable operator psychophysical tolerances. The critical parameters of viewing distance and magnification become increasingly important to visual performance as the altitude increases. It may be concluded, within the limits of this study, that the effectiveness of even the best man-optical system in performing reconaissance is certainly questionable. Thus, feasibility of including an optical system in an orbital vehicle is certainly diminished.

Human Voluntary Tolerance to Vertical Impact. J. J. SWEARINGEN, M.S., E. B. MCFADDEN, M.S., J. D. GARNER, B.S., and J. G. BLETHROW, B.S., FAA Civil Aeromedical Research Center, Oklahoma City, Okla.

Results of several facets of testing of human tolerance to vertical impact forces in standing and sitting positions will be presented. Relative strength of the legs at various knee angles was determined in the standing position by static and dynamic tests. In addition x-ray studies of bone deformation during static loading were made. Human voluntary tolerances to vertical impact were determined during vertical drops while (1) standing with knees stiff, (2) standing with knees bending, (3) squatting, and (4) seated in a rigid chair. In addition, various energy-absorbing materials and devices were evaluated for increasing human tolerance.

The Significance of Blood-Lipid Analysis in USAF Flying Personnel. G. DOUGLAS TALBOTT, M.D., Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

It is apparent that the understanding of lipid metabolism in flying personnel cannot be determined by drawing blood-samples for a single blood-cholesterol count. Blood lipid evaluations were performed on a number of flying personnel under various flight conditions. Lipid analysis involved total lipids, total esterified fatty-acids, triglycerides, cholesterol, cholesterol esters, phospholipids, phospholipid esters, and lipoproteins, determined by electrophoresis. Electrophoretic analysis was done by analytrol scanner and elution methods. Simultaneous silicone whole-blood coagulation times were performed. Reference will be made to drawing conclusions from a single cholesterol determination, and producing "cholesterol cripples" without understanding the entire individual lipid analysis. Blood-samples were obtained from pilots, before and after high-altitude flights in high-performance aircraft, and oxygen saturation studies were done to determine the effect of hyperlipidemia on these individuals. It was found that flying personnel with inherent fat metabolism defect that led to hyperlipidema, following a normal "American" meal, which represents over 50 per cent fat, showed a much greater oxygen saturation uptake. The significance of this increased oxygen demand is discussed in terms of hypoxia in safety for flying personnel. Recommendations are made by specific diets for dietary modifications for such individuals. Comment is made upon the undesirability of decreased blood-coagulation time in the face of hyperlipidemia and its specific relationship to the lipid elements. Discussion of decreased coagulation time in flying personnel subjected to severe stress in high-performance aircraft is given. Slides and charts will be shown, summarizing these biochemical abnormalities. The need for carefully reevaluating biochemical analysis for our flying personnel's lipid metabolism is presented, particularly on pilots who are flying high-performance, high-altitude aircraft, and those who are involved in the space program.

Metabolic Problems in Aviation Medicine. JAN H. TILLISCH, M.D., and JAIME PARIS, M.D., Mayo Clinic and Mayo Foundation, Rochester, Minn.

It is concluded that, with reference to an individual's capacity to safely operate an airplane, diabetes mellitus presents the most controversial situations of the various metabolic derangements and pathological states of the endocrine glands. Consideration is given to difficulties encountered defining the

diabetic and pre-diabetic states, to the disqualifying implications of the need for insulin or oral hypoglycemic agents, and to some diabetic complications which might affect the pilot's career and which have no direct relationship to the severity of diabetes as judged by insulin requirements. The thyroid and parathyroid disease represents a potential threat to a person's physical qualifications to fly an airplane but in most instances such conditions are correctible. The less frequently encountered metabolic diseases must also be considered as potential hazards, these hazards depending on the type and severity of the condition.

Aerospace Accident Reconstruction. COL. FRANK M. TOWNSEND, USAF (MC), Armed Forces Institute of Pathology, Washington, D. C.

It is only by thorough autopsy of the fatalities and correlation with other accident data that the medical officer can give aid to the investigation board in aircraft accident reconstruction. Questions that may be asked after the autopsy is over are, "who was in which seat?," "did the pilot strike the tail surface?," "was there an explosion in flight?," "was hypoxia a factor?" Illustrative cases emphasizing a broad approach and the use of photographs, x-ray examination, and biochemical tests are presented.

Severe Dysbarism in Flight: A Case Report. CAPT. HOWARD R. UNGER, USAF (MC), and CAPT. WILLIAM F. TURNER, USAF (MC), Headquarters Air Materiel Command, Wright-Patterson AFB, Ohio.

The occurrence of severe dysbarism under actual flight conditions has been reported with an increasing frequency in recent years. Severe manifestations of this symptom complex should be anticipated by all physicians concerned with aviation and the problems of flight especially above 30,000 feet. This case report emphasizes the fact that symptoms of severe dysbarism may be confused with the symptoms of hypoxia in experienced flying personnel and that the seriousness of these symptoms, even when recognized as dysbarism, is frequently not appreciated. Methods of duplication, evaluation, and prevention of the symptom complex were successfully demonstrated.

Human Factor Considerations in the Design of the B-58 Escape Capsule. G. A. VALENTINE, Stanley Aviation Corporation, Denver, Colo.

The Convair B-58 will be equipped with an escape capsule in each cockpit. The escape capsule is designed to provide protection in case of cockpit decompression at altitude, permit emergency egress throughout the speed and altitude range of the B-58, and serve as an aid to survival on either water or land under any climatic condition. In the event that cockpit pressurization is lost, the B-58 pilot and crew members can actuate handles which initiate the following series of actions: torso and leg positioning, capsule door closure, and capsule pressurization. The pilot's capsule permits the pilot to fly the aircraft after being encapsulated. Thus, the aircraft can be flown to an altitude where pressurization is not required. Capsule ejection is initiated by the aircraft crew using either or both of the two ejection triggers. The capsule doors provide protection against windblast as the capsule enters the airstream. Careful rocket catapult design and good stability, provided by a stabilization parachute, hold accelerations within human tolerance limits. The stabilization equipment is jettisoned as the recovery parachute is deployed. Landing accelerations are minimized through the use of an impact attenuating air bag. Automatically inflated flotation cells on outriggers are used to provide buoyancy and stability when the capsule lands on water. Critical survival equipment is accessible to the capsule occupant with the doors closed. A complete set of Strategic Air Command survival equipment is provided in each capsule and is readily accessible with the capsule doors opened.

Extra-terrestrial Microbiology. WOLF VISHNIAC, Ph.D., Brookhaven National Laboratory, Upton, N. Y.

Known relationships between microorganisms and their environment make it possible to predict the physiology of the predominant microbial flora in any specified ecological niche. This principle finds its most important application in the "enrichment culture" technique which is used in the isolation of particular microorganisms. By an extension of this reasoning we may formulate informed guesses concerning the microbial population of planets the surface conditions of which are sufficiently well known. As one example the probable physiology of the microorganisms of Mars will be discussed. Since Mars provides an illuminated, CO_2-rich, anaerobic environment, photosynthesis must be of the bacterial (that is, non-oxygen evolving) type. The reduction of carbon to organic matter can be counterbalanced by a variety of anaerobic respirations, such as sulfate reduction, denitrification, methane fermentation, et cetera. Other possible types of microbial ecologies will be mentioned. A device will be demonstrated which may

serve to detect the existence and telemeter the activities of Martian microorganisms.

Diagnosis of the State of Health of a Man in Space. JAMES N. WAGGONER, M.D., The Garrett Corporation, AiResearch Manufacturing Division, Los Angeles, Calif.

The author presents a summary of the physical findings of a human occupant of the Project Mercury capsule during recent testing at sea level and at altitude. Film recordings made during the testing will be presented. A discussion of the medical information needed to properly ascertain the individual's state of health will be presented, with a consideration of the instrumentation necessary to convey this information. Finally, there will be consideration of how such knowledge can eventually be applied to all fields of medicine to better understand body physiology in its normal state and during disease processes.

The Full Range of Cerebral Vascular Response to Alteration in Arterial Carbon Dioxide Tension. A. J. WASSERMAN, M.D., and J. L. PATTERSON, JR., M.D., Medical College of Virginia, Richmond, Va.

Blood gas tensions are the principle factors in the intrinsic control of the cerebral circulation. This report describes the full range of cerebral vascular response to P_{aCO_2} (arterial carbon dioxide tension). In nineteen experiments on eleven normal adult men, CBF (cerebral blood flow) was monitored continuously by an oximetric technique during hyperventilation and its consequent hypocapnia. Cerebral vasoconstriction was initiated by a reduction of P_{aCO_2} of 2 mm. Hg. and CBF was reduced 25 per cent by a 12 mm. Hg. decrease in P_{aCO_2}, achieved by moderate hyperventilation. Maximal hyperventilation with extreme reduction in P_{aCO_2} did not decrease CBF more than 40 per cent (below which level signs of cerebral ischemia are known to result). Thus, as hypocapnia increases, the strength of physiologic antagonists (vasodilators) increases and the brain is protected from extreme reduction in CBF. These vasodilator factors are the lower end-capillary P_{O_2} and higher P_{CO_2} resulting from constant cerebral metabolism with lowered CBF and the respiratory alkalosis. On the other hand, cerebral vasodilation induced by breathing mixtures of high CO_2 content, is opposed only by the weak constrictor influences of acidosis and increased P_{O_2}. The data from three subjects, breathing 8 per cent CO_2 in air, were pooled with previous studies in this and other laboratories to give the full range of response to hypercapnia. After a rise of 4 mm. Hg. P_{aCO_2}, vasodilation ensued and progressed rapidly so that an increase of P_{aCO_2} of 15 mm. Hg. doubled and of 38 mm. Hg. tripled the CBF. Calculations show that with constant cerebral metabolism, an increase or a decrease of CBF of about 30 per cent, secondary to changes in cerebral perfusion pressure, will result in alterations in end-capillary P_{CO_2} which will initiate vasoconstriction or vasodilation, respectively. These data, in particular the response to decrease in P_{aCO_2}, beside their intrinsic physiologic interest, bear on problems of aerospace medicine. Anxiety induced hyperventilation, for example, need be of relatively small magnitude to produce physiologically significant vasoconstriction in the brain.

The Effect of Weightlessness on Some Postural Mechanisms. SQ. LDR. T. C. D. WHITESIDE, Ph.D., RAF Institute of Aviation Medicine, Farnborough, England.

The performance of an aiming task in which a subject has to point to the center of a target before him, depends on the coordination of visual information with intact proprioceptive and efferent mechanisms. When the task is carried out with the eyes closed, some verification of performance is still possible—especially if the hand is brought back to touch the nose as in the well-known clinical test. Such an aiming test with eyes closed has seen carried out while the subject was exposed to different G forces including zero-G. In addition, subgravity was simulated by water immersion which of course affected only muscle joint sense and not the utricular otoliths. When the balance of anti-gravity muscles was altered by one of these procedures, the tests showed an initial inaccuracy of aim, followed by an improvement with time and experience. The loss of orientation in an aircraft cabin which is immersed and filled with water is most probably due to this altered muscle balance, together with the absence of visual information and the reduced proprioceptive clues as to the direction of the vertical. In the flight experiments on zero G, tendon reflexes were present, but in laboratory experiments carried out by dropping subjects, it was found that the myotatic reflexes elicited by tapping the tendo achilles, disappeared shortly after the onset of zero G, reappearing about 100 m./secs. later. This was probably associated with the steplike change from one to zero G and it seems that the responsible factor was the resultant passive movement of the leg muscle together with consequent shortening of the muscle spindle. It was found that even when the subject was not

dropped, a small extension of the foot about the ankle joint produced a similar disappearance of the ankle jerk for about 100 m./secs. The re-appearance of the response after this time appears to be due to the re-establishment of spindle tone by supra spinal control. It is unlikely that labyrinthine factors were responsible for the temporary loss of tendon reflex under zero G, since the time at which the reflex disappeared was not cause to vary by varying the time at which the head became weightless relatively to the leg.

Man's Cardiovascular Response to Headward Acceleration While Immersed in Water. EARL H. WOOD, M.D., EVAN F. LINDBERG, M.D., CHARLES F. CODE, M.D., and EDWARD J. BALDES, Ph.D., Mayo Clinic and Mayo Foundation, Rochester, Minn.

Variations in ear opacity, ear opacity pulse, heart rate, respiration and reaction times to auditory and visual stimuli were recorded continuously in a series of 15 subjects during 15-second exposures to acceleration while seated in a steel tub mounted in the cockpit of the Mayo centrifuge. The level of acceleration was increased by increments of 0.5 to 1.0 G until complete loss of vision (blackout) was produced when the tub was empty (control) and when filled with water to the level of the xyphoid and also to the third rib at the sternum. A total of 200 centrifuge exposures to accelerations ranging from 2.0 to 9.0 G was carried out. The protection afforded against visual symptoms by immersion in water to these levels has been reported previously (*Fed. Proc.*, 5:327, 1946). This analysis was carried out (1) to determine if, except for the increased levels of acceleration required to produce given effects, immersion in water significantly altered the basic pattern of cardiovascular responses elicited by headward acceleration in relaxed trained centrifuge subjects; and (2) to study the relationship between the protection afforded against visual symptoms and the objective alterations in the heart rate and circulation to the head (ear). No systematic alterations in the general pattern characterized by a period of failure during the first 5 to 10 seconds followed by cardiovascular compensation and recovery from visual symptoms during the latter part of the exposure were observed during immersion in water. The average periods from the onset of the plateau level of acceleration to the loss and subsequent recovery of responses to light signals in the peripheral field of vision of 5.6 $\pm$ 0.3 and 13.2 $\pm$ 0.6 seconds were not significantly altered. The times to minimal ear opacity, ear opacity pulse, and maximal heart rate of 8.3 $\pm$ 0.4, 5.4 $\pm$ 0.2 and 8.0 $\pm$ 0.3 seconds were unchanged or slightly less. The decrements in ear opacity associated with the various degrees of visual impairment were closely similar; however, the decrements in ear opacity pulse and increments in heart rate were significantly less during immersion in water than when in air. The average values for protection afforded by immersion in water to the third rib against loss of vision and the above three objective variables were 1.8 $\pm$ 0.1, 1.8 $\pm$ 0.1, 2.7 $\pm$ 0.2 and 2.9 $\pm$ 0.2 G, respectively. It is believed that at head level a higher blood pressure is required to maintain vision during immersion in water than when no external pressure is applied to the lower part of the body; and that the protection afforded to blood pressure at head level and to maintenance of consciousness is greater than the protection afforded to vision.

Respiratory Effects of Forward Acceleration. FRED W. ZECHMAN, Ph.D., CAPT. NEIL S. CHERNIACK, USAF (MC), and CAPT. ALVIN S. HYDE, USAF (MC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

Since it is likely that pilots of rocket propelled vehicles will experience forward acceleration and since respiratory difficulties limit tolerance in this position, further studies have been conducted to determine the effect of forward acceleration on respiration. Two series of experiments were conducted. In the first the influence of forward accelerations of 5, 8, and 12 G on respiratory frequency, tidal volume and nitrogen elimination have been studied. In the second series, the effect of forward accelerations of 5, 8, 10, and 12 G on oxygen consumption has been measured. Respiratory frequency increased and tidal volume decreased with increasing acceleration. Frequencies reached 39.2 cycles per minute at 12 G while tidal volume fell to 318 cc. The nitrogen eliminated during a 30-second period of oxygen breathing did not decrease suggesting that gross alveolar ventilation probably did not decrease. Oxygen consumption increased with increasing forward acceleration. Several factors presumably are responsible including the extra work in breathing and an increase in muscle tone.

Short Time Human Tolerance to Sinusoidal Vibrations. GERD H. ZIEGENRUECKER, M.D., and CAPT. EDWARD B. MAGID, USAF (MC), Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

Short time human tolerance criteria for sinusoidal vibration from 1 to 15 cps were determined using ten healthy male subjects ranging in age from twenty-three to thirty-

four years. At each frequency, the amplitude was increased at a constant rate from zero to the point where the subject stopped the run because he thought that further increase might cause actual bodily harm. The lower levels of tolerance were found to be between 1 and 2 G at 3-4 cps and at 7-8 cps. The highest tolerance level of 7-8 G was found at 15 cps. Subjective tolerance limits were found to be caused by one or more of seven specific sensations or symptoms. Physiological observations during vibration exposure were also made.

The Role of a Flexible Cockpit in Human Engineering Research. RALPH B. ZIEGLER, M.A., NEAL M. BURNS, Ph.D., JOHN LAZO, and EDMUND C. GIFFORD, B.A., Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pa.

A flexible cockpit was recently developed at this laboratory for use in a series of basic and applied anthropological studies of pilot mobility. The structural features of this apparatus are discussed in relation to these studies and their contribution to aircraft work-station design. Two preliminary projects concerned with evaluation of the functional mobility aspects of pilots in the Navy Mark IV full pressure suit are described. One involves distance and torque measurements under various experimental conditions; the other was a general mobility study done in conjunction with Project Mercury. A discussion of the results obtained to date and their implications for further research will be presented.

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Medical and Administrative Pitfalls of the Civil Aviation Flight Surgeon. J. H. BRITTON, M.D., Federal Aviation Agency, Washington, D. C.

The medical pitfalls are almost entirely in those fields wherein there is a lack of definite medical knowledge. This is particularly true as it applies to the cardiovascular system, the central nervous system and the respiratory system. The administrative pitfalls are primarily concerned with dependence upon large numbers of designated examiners and the attempt to find a middle ground between good medical practice and public opinion.

Review of the First Several Thousand Airline Pilots' Electrocardiograms. J. H. BRITTON, M.D., Federal Aviation Agency, Washington, D. C.

This will be a classification and enumeration of the various abnormalities found among these electrocardiograms and the discussion of the philosophical approach necessary in processing them. A comparison will be made of the defects found with those of the Air Force study. The age distribution of this group will also be noted.

Interrelationships of Bio-astronautics and Research in the Field of Biological Orientation. S. R. GALLER, Ph.D., Head, Biology Branch, Department of the Navy, Office of Naval Research, Washington, D. C.

The rapidly evolving field of bio-astronautics embraces many scientific disciplines and research specialties including biological orientation research. Biological orientation investigations may be described as efforts aimed at examining a wide variety of organisms as biological models possessing unique characteristics which man is attempting to duplicate by means of mechanical and/or electronic analogue systems. For example, many animals possess abilities to identify and select targets and navigate with unerring precision to these targets from over great distances. This paper will be devoted to a partial description of the unique abilities of certain organisms to function in ways which appear to be relevant to some research objectives in the field of bio-astronautics. The paper will also suggest a number of types of investigations aimed at providing fundamental data pertinent to bio-astronautics.

Newer Problems of Carrier Aviation. CAPT. M. H. GOODWIN, MC, USN, Station Hospital, USN Air Station, Quonset Point, R. I.

In spite of the current trend toward guided missiles, space vehicles and obsolescence of conventional aircraft, the aircraft carrier and carrier aviation will probably continue to comprise an important aspect of national defense for some time to come. With present-day high performance carrier aircraft, very real and complex problems are encountered. Among the problems discussed are high intensity noise and its multiple effects on personnel and communications; use of full pressure suits and the problems generated by their use aboard ship; problems associated with the use of liquid oxygen aboard ship; full medical coverage of personnel in the modern, fast Carrier Task Force concept; and finally, various problems of flight deck operations and flight deck safety in general.

Human Factor Causes of Aircraft Accidents. COL. K. E. PLETCHER, USAF (MC), Norton AFB, Calif.

Significant recurring human factor causes of aircraft accidents are specified. Each cause factor is discussed briefly in relation to corrective action which can be taken to preclude accidents from that specific cause. A brief statistical summary of unclassified USAF accident experience is included.