AD 410335

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA

ROMEDICAL EVALUATION FOR SPACE PILOTS

US Aerospace Medicine
Division (AFSC)
Brooks Base, Texas

AEROMEDICAL EVALUATION FOR SPACE PILOTS

Edited by
Lawrence E. Lamb, M. D.
Professor of Internal Medicine
Chief, Clinical Sciences Division

USAF School of Aerospace Medicine
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas
July 1963

LIST OF CONTRIBUTORS

Donald R. Bennett, Captain, USAF, MC
Chief, Neurology Section
Neuropsychiatry Department

Robert A. Brolling, Captain, USAF, DC
Clinical Dentistry Department

William B. Clark, Captain, USAF, MC
Ophthalmology Department

James R. Clay, Major, USAF, MC
Chief, Pathology Department

John M. Connolly, Major, USAF, MC
Chief, Experimental Surgery Department

Robert L. Cramer, Ph. D.
Vestibular Laboratory
Ear, Nose and Throat Department

James F. Culver, Lt. Colonel, USAF, MC
Chief, Ophthalmology Department

Roy Danford, Jr., B. A.
Audiology Laboratory
Ear, Nose and Throat Department

Patrick J. Dowd, M. A.
Vestibular Laboratory
Ear, Nose and Throat Department

Harold V. Ellingson, Colonel, USAF, MC
Commander, USAF School of Aerospace Medicine

Don E. Flinn, Lt.Colonel, USAF, MC
Chief, Neuropsychiatry Department

Alfred Hamilton, Lt. Colonel, USAF, MC
Chief, Ear, Nose and Throat Department

Bryce O. Hartman, Ph. D.
Neuropsychiatry Department

Robert L. Johnson, Lt. Colonel, USAF, MC
Chief, Internal Medicine Department

Lawrence E. Lamb, M. D.
Chief, Clinical Sciences Division

Ward B. Litton, Captain, USAF, MC
Ear, Nose and Throat Department

Richard E. McKenzie, Ph. D., Major, USAF, MC
Neuropsychiatry Department

Perry B. Miller, Major, USAF, MC
Internal Medicine Department

Douglas H. Powell, Ed. D., 1st Lt., USAF, MC
Neuropsychiatry Department

Charles L. Randolph, Jr., Major, USAF, MC
Chief, Radiology Department

Sanford L. Severin, Captain, USAF, MC
Ophthalmology Department

Harrell C. Sutherland, Jr., M. Ed.
Audiology Laboratory
Ear, Nose and Throat Department

Raymond O. Waters, Major, USAF, MC
Ear, Nose and Throat Department

Carlos O. Welch, Jr., Captain, USAF, MC
Internal Medicine Department

Lester F. Williams, Jr., Captain, USAF, MC
Experimental Surgery Department

Morgan E. Wing, Major, USAF, MC
Ear, Nose and Throat Department

Granville J. Womack, Major, USAF, MC
Chief, Aviation Medicine Department

TABLE OF CONTENTS

FOREWORD

The principle of matching a man's physical capabilities to the requirements of his job is a fundamental one, whether the job is military or civilian. Great varieties of physical standards have been developed, for soldiers, for workers in various industries, for pilots of conventional aircraft, and for many others. Over a period of years most selection criteria have been validated by the study of persons selected as they performed their tasks. Information developed in such studies has permitted further refinement of the criteria.

As man has extended his travels into space, the selection of space vehicle operators has received a great deal of attention. Several factors in the space environment are different from any previously encountered. Weightlessness, radiation, exposure to high G-forces, and confinement, are but a few of the stresses which alone or in combination will have their effects on the space traveler. As space journeys become longer, remoteness from medical support increases. Probably no other occupation places greater demands on the operator, in terms of task complexity, judgment, and performance under a variety of stresses. All these facts have emphasized the importance of selecting persons most likely to succeed in this exacting occupation.

This volume describes an integrated medical examination procedure developed at the USAF School of Aerospace Medicine for selection of Air Force Space Test pilots. Through an exceptionally detailed history and an intensive and complete medical evaluation, the School staff has made certain that selectees have been -- within the limits of our present information -- physically qualified to withstand the stresses they encounter. Included in this report are findings from the examination of the first group of space test pilot candidates. Regardless of criteria to be validated through experience, we feel that this examination has permitted selection of trainees with excellent prospects for performance in the space environment.

Harold V. Ellingson

HAROLD V. ELLINGSON
Colonel, USAF, MC
Commander, USAF School of Aerospace Medicine

INTRODUCTION

Lawrence E. Lamb, M. D.

The medical support for any mission encompasses three fundamental areas; these are, first, the medical aspects of selection of personnel; second, the medical aspects of training for the mission; and third, the maintenance of health of individuals while performing the mission.

The first of these, the medical aspects of selection, has long been the traditional part of the entrance of individuals into the Armed Services. The nature of such examinations has evolved in accordance with the needs of the mission itself. When individuals were required primarily to shoulder a rifle and confined to earth operations, the medical examinations were somewhat limited in scope. With the advent of the airplane it became necessary to introduce a more sophisticated method of medical examination. These examinations are referred to as aeromedical evaluations. Minor physical findings became of greater significance. Asymptomatic obstruction of the sinuses and nasal passages or other minor defects were quickly recognized as incompatible with sudden changes in altitude associated with military flying. Visual acuity became of much greater importance because of the high premium placed upon visual perception in aerial flight, particularly in a combat mission.

The mission requirements demanded an element of quality control. The machine was useless in performing its mission without the human occupant and the performance of the machine was limited to the performance capability of its master. As aircraft and aerospace vehicles have become progressively more expensive and as the training programs have become more costly and time consuming, the value of the human component has become an increasingly important economic factor. On the basis of time and expense involved one cannot afford to recommend an individual that has any medical findings which could in any way cut short his participation or ultimate utilization in such a program.

Aeromedical evaluations necessarily deal with information distinctly different from that obtained from hospitals and clinics. It must be emphasized that the majority of information from the medical community has been obtained from sick people. The physician ordinarily sees individuals who come to him because they are ill or think they are ill. This is the great body of experience from which most of our knowledge has been gained. By contrast, when one is dealing with subjects undergoing aeromedical evaluations for aviation or space missions, one is dealing with individuals who think they are well and who appear to be in good health. While medicine has learned a great deal about the acute phase of disease or the acute complications of disease, it has learned far less about the early detection of disease in the asymptomatic individual or the significance of isolated medical findings in the apparently healthy subject. Such knowledge can only be gained from the longitudinal study of individuals outside the hospital environment. The true significance of isolated medical findings noted on aeromedical evaluation can only be assessed if knowledge concerning an apparently healthy population has been gained.

To cite one example, the Wolff-Parkinson-White syndrome illustrates the problem. Most reports in the literature indicate that approximately 70 percent of the individuals with this finding have recurrent paroxysmal atrial tachycardia. In the past when individuals with this finding were detected they were removed from flying duties because of the hazard of recurrent arrhythmias. Since this is solely an electrocardiographic finding, only those individuals with symptoms were the ones who usually went to the hospital or clinic. Those individuals with this electrocardiographic abnormality who did not have symptoms did not have any occasion to see a physician and therefore were unrecognized. The symptomatic pre-selected population is adequate reason for the clinical impression that 70 percent of these individuals had paroxysmal arrhythmias. The accumulation of information on approximately 250,000 flying personnel has provided a means of studying this electrocardiographic finding in an apparently healthy population. It has been found that the incidence of paroxysmal atrial tachycardia in such a pre-selected population is as low as 12 percent. This is at distinct variance from the impression one gains from hospital or clinic data. It is only by the evaluation of very large populations in a non-hospital environment that the true natural history of diseases can be determined. The acquisition of such knowledge is not only essential to the medical aspects of selection of an aerospace crew but it provides major benefits to the clinical practice of medicine.

The USAF School of Aerospace Medicine, throughout its history, has accumulated data of significance to evaluation of flying personnel. This has been done by an extensive research program coupled with the development of a referral consultation service to evaluate aeromedical problems originating throughout the United States Air Force. Those aeromedical problems specifically related to flying that require extensive evaluation are examined in detail by the Clinical Sciences Division of the USAF School of Aerospace Medicine. Through the years of this program a vast amount of information has been obtained relative to the significance of medical findings in the flying personnel, normal values in an apparently healthy population, and the influence of various medical findings on the continued participation in flying duties.

In the course of development of the specialized consultation service many diagnostic techniques and procedures have been developed. These have been evaluated as far as their applicability to problems of aeromedical evaluation is concerned. Each individual referred for aeromedical evaluation is studied intensely. The various specialists are oriented toward the application of their specialty problems to the needs of aerospace medicine. Finally, after the whole-man evaluation has been accomplished by all different specialty areas his case is carefully reviewed by the various specialty groups that have evaluated him and a recommendation concerning his health and future participation in aerospace missions is made.

The procedures used in the aeromedical evaluations for space pilots are in every instance procedures that have been developed and proved in their regular use and application to actual referred aeromedical problems. There are no procedures in the aeromedical evaluations for space pilots that have not been proved and utilized in this manner. The significance of observations made in the space pilot evaluations can be quickly correlated with the wealth of material that has been accumulated over years in depth by this program.

To illustrate, because of the problems of syncope and loss of consciousness in the flying personnel as related to the individual's capacity to continue flying duties, many individuals have been evaluated for this problem at the USAF School of Aerospace Medicine. This has resulted in an improvement in our knowledge of the incidence of syncope, its importance in reference to flying duties, and it has enabled us to develop methods of evaluation in such instances. The wealth of information which has been accumulated on tilt table studies for evaluation of orthostatic stresses is one example of this application to the space pilot evaluations.

In certain specialty areas there is an exceptional wealth of material which has direct application to evaluations of space pilots. One of these outstanding areas is the USAF Electrocardiographic Program. In 1957, prior to the time of Sputnik, the United States Air Force established a central library for all electrocardiograms on its entire flying population. Since that date nearly a quarter of a million records have been accumulated. This includes individuals on flying status between the ages of 16 and 60 years. It includes all those individuals who are applicants to the Academy and receive electrocardiograms as an applicant examination to flying training. This has provided us an immediate wealth of information concerning the incidence of various electrocardiographic findings, their correlation with different age groups, and an opportunity to follow these findings in a longitudinal manner. Many procedures have been developed to evaluate individuals with electrocardiographic findings. The specialized electrocardiographic studies used in the space pilot evaluation were developed to evaluate such findings in the Air Force flying population. Such procedures include the monitoring of the electrocardiogram during multiple variables including respiratory maneuvers, orthostasis, postprandial influences, and a host of others. Without this wealth of material to provide a cornerstone for judgment, it is not likely that minor variations noted in space pilot evaluees could be properly assessed. The results from these studies have all been published in the medical literature.

To illustrate further the application of such cornerstone information to the aeromedical aspects of space, this material provided the basis to develop the first course given on electrocardiographic monitoring during space flight. Those physicians responsible for monitoring the Mercury flights throughout the world were trained in electrocardiographic monitoring at the USAF School of Aerospace Medicine. The unique establishment of this type of information made this possible. The techniques used for testing individuals during maximum exertion, tilt table studies, respiratory maneuvers and other procedures were applied to each individual participating in the Mercury flights. This material recorded on magnetic tape was used in part to assist in teaching the medical monitors the individual physiological variations of each subject.

The USAF School of Aerospace Medicine has actively carried out a program of aeromedical evaluation for space pilots. The majority of the graduates of the USAF Test Pilot School since July 1959 have undergone extensive evaluation at the USAF School of Aerospace Medicine. These evaluations have been used specifically for the selection of space pilots for the USAF. Although the development of these methods of evaluations have been by the staff of the USAF School of Aerospace Medicine as a result of Air Force missions as described above, this method of evaluation has been used for other government agencies as requested. In this sense the aeromedical evaluations of the type used for space pilots in the United States Air Force are done by the staff of the USAF School of Aerospace Medicine as a service to other requesting agencies.

The ultimate goal in the aeromedical evaluation of personnel for space crews is to identify individuals who are most likely to successfully complete training and participate on a long term basis in such missions without medical impairment, either physical or mental. Because of the exacting requirements and length of time involved in such missions, the occurrence of physical or mental disorders can seriously jeopardize the successful execution of space missions. The importance of such missions requires that each candidate undergo a comprehensive aeromedical evaluation to determine his fitness for these duties.

The aeromedical evaluation may be considered in four phases; the first of these is the detection of significant disease processes or abnormalities. The aeromedical evaluation is sufficiently comprehensive not only to detect obvious abnormalities but also to detect abnormalities frequently not apparent by history and physical examination alone. In this category findings of renal stones, silent gallbladder stones, evidence of peptic ulcer, evidence of a convulsive focus of the brain, dental apical abscesses,rectal polyps, diabetes, and many other abnormalities must be detected. Their presence may seriously limit the likelihood of prolonged successful participation in space missions.

The second area encompassed in the aeromedical evaluation are findings which may predispose to disease or limit performance capability. A number of findings may be noted on medical examination which increase the likelihood of disability even though they do not permit a diagnosis of disease or abnormality. Obesity, for example, is associated with a significantly higher incidence of medical abnormality. In this group also are the individuals with borderline glucose tolerance tests, classified as probable diabetes. Many authorities feel that individuals with this characteristic are more likely to develop significant clinical diabetes at some future date. Since the objective of aeromedical evaluations for space programs is to provide a pool of individuals least likely to develop medical abnormalities, these factors necessarily must be considered in an aeromedical evaluation for space pilots. The range of their importance can only be assessed by careful evaluation of a large number of selected personnel such as provided by large military flying populations.

The third area of the aeromedical evaluation concerns itself with the assessment of mental and character dynamics. This is a complex evaluation of the candidate's motivation, his intellectual ability, learning aptitude, emotional adaptability, and maturity. Eligibility of a candidate for evaluation validates to some extent adequate mental and character dynamics on the basis of his past performance. This is particularly true when test pilot graduates are used. Factors related to his motivation for participation in space flight and emotional patterns noted during past performance are major facets of this evaluation. Character and personality traits such as dependability, judgment, and social factors which may influence the candidate's performance or retainability are considered. When the using agency requests a large battery of psychological tests they are performed. The USAF School of Aerospace Medicine has the capability of carrying out these procedures. They are included in this report to illustrate their use and application in such programs. It must be understood, however, that their inclusion for selection of individuals to continue into advanced aerospace projects has far less value than their use in selecting individuals to begin their flying career. Performance tests are somewhat in the same category wherein the individual on a daily basis has proved himself to be highly successful in the most complicated performance task of all which has a direct application to aerospace missions, namely the continued and recurrent flying of high performance aircraft under varying circumstances. In other words, in this particular sphere an element of self-selection has already been accomplished. The amount of psychological testing used for the Air Force missions is for this reason curtailed.

Frequently individuals evaluated for Air Force missions are not evaluated on a competitive basis since all subjects have been selected unless some significant medical abnormality precludes their participation in such programs. When an agency is evaluating far more candidates than they intend to appoint, such psychological tests may provide additional information which would be useful to the using agency in the same manner that such data is important to the personnel section of an industry in the acquiring of new personnel.

The fourth facet of the aeromedical evaluation is the emphasis upon physiological capacity just as an automobile, airplane, or aerospace vehicle must be tested in terms of its performance characteristics such as speed, horsepower, utilization of fuel, ... tics, the human body may also be studied. The huma... ...ris- magnificant machine and can be studied during performance. It is ... siderable importance to know how the individual functions during work. This is accomplished by different procedures such as the study of the individual during maximum exertion, the use of the tilt table studies for autonomic control of the central nervous system, and combinations of physiological stresses including common respiratory maneuvers such as hyperventilation, breath holding combined with orthostatic influences. By maximum stress testing such as maximal physical effort combined with suitable measurements which record the function of the heart as a pump, the fluid dynamics of the circulatory system and the ventilation of the lungs, the physiological capacity of an individual subject can be expressed. This requires the simultaneous recording of multiple biological signals during periods of stress testings or a dynamic approach. This is in direct contradistinction to the usual clinical situation in which an individual presenting with disease is studied in the resting or idling condition and presents a disability that is apparent at rest or during idling circumstances.

It is to be emphasized that the aeromedical evaluation does not have the capability of predicting who will subsequently have disease. It is not done with this purpose in mind. It is well understood that the state of the medical art at this date has not advanced to such a degree to permit such predictions by any examining facility. It is the intent, however, to give as searching an examination as possible within the state of current knowledge to assess the candidate's aeromedical status. This is essential to the detection of overt disease.

The aeromedical evaluation does not provide the basis for selection of individuals to enter into space programs. It is a necessary and useful heal[illegible] [illegible] insures the probability that individuals in the best state of not responsible for [illegible] USAF School of Aerospace Medicine staff is a consulting agent. Its reports are [illegible] such programs. It acts as the using agency or to the appropriate medical segments [illegible] component of The using agency does not necessarily follow the recommenda[illegible] Air Force. USAF School of Aerospace Medicine and accepts full responsibili[illegible] of the final selection of its candidates. In this sense the Clinical Science Division, USAF School of Aerospace Medicine, acts in a consulting capa[illegible] providing the best quality and the most comprehensive examination it can, accompanied with its best recommendations concerning the aeromedical aspects of each candidate.

SCHEDULING

Lawrence E. Lamb, M. D.

The examination schedule includes multiple complex tests done in a short span of time. Many of these tests tend to interfere with each other. Because of this, special attention should be given to the scheduling of all candidates. As will be noted there is almost no free time for any candidate through a five-working-day period. This requires greater attention than can probably be given to more than a few individuals at a time. The program, however, is designed to study intensively a small number of people rather than a large mass of people less thoroughly.

In order to provide for uniformity to testing, all subjects were given an instruction sheet covering their five days of testing in addition to all verbal instructions. Each subject also received a five-day schedule sheet, both of these are attached. In order to make maximum use of the facilities individuals are processed on two different schedules simultaneously, Schedule A and Schedule B. Instructions and schedules are included in the following pages.

TEST PILOT INSTRUCTION SHEET

FIRST DAY

Report to the Laboratory, Room 161, fasting where your blood samples and urine samples will be taken. After you have drunk your glucose water used for your sugar metabolism test you should report to Room 183 to meet Dr. Lamb, Chief of the Clinical Sciences Division. This will be a very short meeting. Thereafter you will return to the Laboratory for the first blood sample which should be drawn 30 minutes after you have finished drinking your glucose water. After this blood sample has been drawn you should report back to Room 184 where your picture will be taken. You should then return to the Laboratory for the next blood sample on your glucose tolerance. Following this blood sample (approximately 0915 hours) you should report to Dentistry, Room 152, where your dental x-rays will be taken. During the time you are having your sugar metabolism studies done you should not drink any coffee or smoke any tobacco. You should have reported at the Laboratory fasting and the only intake which is permitted until the test is entirely through is tap water. The rest of the day's schedule is as indicated on the Schedule Sheet that has been given to you.

In the evening you should have no alcohol for any night preceding any of the five days of testing. The first evening you may follow your normal dietary habits with the omission of alcoholic beverages. Get a good night's sleep each night during the period of testing.

SECOND DAY

You would be well-advised to eat a light breakfast if it is your custom to have breakfast and avoid an excessively heavy breakfast because you will be doing physical exertion and performance type tests. After completion of your day's testing, again, you should avoid alcohol and follow your normal dietary habit.

THIRD DAY

Be sure to eat a normal breakfast and report to Building 100 for the day's schedule as outlined. During the day be certain to obtain your Lugol solution which must be taken prior to the time of your testing scheduled for the following day. This is indicated on your schedule. Also, you should be certain to pick up some gallbladder dye pills from the Scheduling Desk in Building 100 where you reported in. At the end of this day your evening meal should consist only of tea and toast. Do not eat any eggs, cream, milk, butter or anything which has fat in it. Do not put butter on your toast. Beginning at 2000 hours, take the gallbladder dye tablets, taking one each at 5-minute intervals with a small amount of water. Do not smoke after midnight and remain fasting from 2000 hours on.

FOURTH DAY

Do not eat breakfast or drink coffee or water. Report to X-ray in the fasting state. Do not smoke. At 1000 hours return to your normal dietary habits and smoke if you so desire. After the completion of the day's schedule you may eat a normal meal, avoid alcohol and do not drink or eat anything after midnight.

FIFTH DAY

Report to Room 116, Building 100, to drink your heavy water to be used to determine the amount of water content in your body which enables calculation of percentage of body fat. You should report in the fasting state. Do not drink any water or eat. At the time of reporting you should urinate and evacuate your bowels prior to taking the heavy water. After you have drunk the heavy water in the presence of the technician, he will note the time it has been administered. Once the water has been drunk it is absolutely essential that you do not eat or drink anything and that you do not urinate or move your bowels until after your blood sample has been obtained in Room 116 four hours after the completion of administration of the dose. The technician will notify you of the time you should report back to his room for the blood sample. Be certain to keep this appointment accurately.

After this blood sample has been withdrawn you may return to your normal dietary and beverage habits.

SCHEDULE A

0800	Laboratory Rm 161	Tilt Table Rm 114 Treadmill Rm 114	EEG Rm 171	X-ray Rm 146	0800 Total Body Water Rm 114 0815 Dentistry Rm 152 0830 Pul Func Rm 114
0900		Valsalva Rm 114 Cold pressor Rm 114	0930 CBS Rm 171	Sigmoidoscopy Rm 114 0930 Blood Vol Rm 114	
1000	Int Med - History & Px Rm 114	X-ray Rm 146	1030 Aptitude Testing Rm 171	Ophthalmology Rm 136	1000 Dr.Flinn Rm 171
1100		Ophthalmology Rm 136	Aptitude Testing Rm 171	Neurology Rm 171	Avn Med Rm 103
1200	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
1245	Int Med - ECG Rm 114 Precordial Map	Ophthalmology Rm 136 ↓	Psychiatric Interview Rm 171	Clinical Psychological Testing Rm 171 ↓	
1345	Special Studies Rm 114 Double Master	↓	Psychiatric Interview Rm 171	↓	
1445	Vectorcardiogram Rm 114 Phonocardiogram Rm 114	↓	ENT Rm 131	↓	
1545	Plethysmogram	↓	ENT Rm 131	↓ 6 P. M.	

SCHEDULE B

0800	Laboratory Rm 161	Tilt Table Rm 114	Apitude Testing Rm 171	X-ray Rm 146	0800 Lab Rm 161 0815 Tot Body water Rm 114 0830 Dentistry Rm 152
0900		Valsalva Rm 114 Cold Pressor	0930 EEG Rm 171	Blood Volume Rm 114 0930 Sigmoid-oscopy Rm 114	0900 N.P. Dr. Flinn Rm 171
1000	Int Med - History & Px Rm 114	1015 X-ray Rm 146		Neurology Rm 171	1000 Pulmonary Functions Rm 114
1100	Int Med - History & Px Rm 114	Ophthalmology Rm 136	CBS Rm 171	Ophthalmology Rm 136	1000 Pulmonary Functions Rm 114
1200	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
1245	Int Med - ECG Phonocardiogram Rm 114	Ophthalmology Rm 136 ↓	ENT Rm 131	Clinical Psychological Testing Rm 171 ↓	Aviation Medicine Rm 103
1345	Special Studies Rm 114 Double Masters Rm 114	↓	ENT Rm 131	↓	
1445	Vectorcardiogram Rm 114 Phonocardiogram Rm 114	↓	Psychiatric Interview Rm 171	↓	
1545	Plethysmogram Rm 114	↓	Psychiatric Interview Rm 171	↓ 6 P. M.	

Prior to the patient's arrival form letters notifying him of his appointment were sent to his base. This letter included instructions for completing the extensive aeromedical survey for history taking purposes which will be detailed in the subsequent chapter. It also included instructions to his referring flight surgeon as well as instructions for patient preparation prior to testing (see attachments).

USAF SCHOOL OF AEROSPACE MEDICINE
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS

REPLY TO
ATTN OF: SMKA

SUBJECT: Aeromedical Evaluation

TO:

1. Appointments have been made in Clinical Sciences Division, for ____, beginning 0800 hours, ________________. This evaluation is on an outpatient status and will take approximately ten (10) days. He should be placed on TDY in accordance with paragraph 4c, AFR 160-103, and report to the Reception Desk, Flight Medicine Laboratory (Bldg. 100), Brooks AFB, Texas, at the above time and date.

2. If complete Health Records, including those of previous hospitalizations, consultations, special procedures, all outpatient records and x-rays, have not already been forwarded this facility, request they be obtained and sent to us by certified mail to arrive here not later than ________________.

3. Aeromedical Survey attached - to be completed by the patient and forwarded with medical records. Request the referring Flight Surgeon add his comments and other pertinent data, that is discussion of the patient's history, his reaction to stresses of aviation, and a statement concerning motivation for military flying, to the Subject's Medical History (Aerospace Med Cen Office Form 38A), so his opinions and findings may be made a permanent part of the patient's aeromedical evaluation.

4. Diet and fasting instructions are attached for delivery to the patient.

5. Co-ordinated schedules are pre-arranged at this facility for evaluation patients to minimize their stay and preclude excessive expenditure of TDY funds. Failure to receive all medical records, late reporting, or arriving in a non-fasting condition will necessitate re-scheduling and undue delay in completing the evaluation.

6. On base billeting reservations have been made for the day preceding first appointment.

FOR THE COMMANDER

LAWRENCE E. LAMB, M. D.
Chief, Clinical Sciences Division

Atch
1. Aeromedical Survey
2. Diet & Fasting Instructions

USAF SCHOOL OF AEROSPACE MEDICINE
AEROSPACE MEDICAL DIVISION (AFSC)
Brooks Air Force Base, Texas

DIETARY & FASTING INSTRUCTIONS FOR EVALUATION PATIENT

____
(NAME)

____
(APPOINTMENT DATE)

The following instructions must be followed so that each patient who arrives at the USAF School of Aerospace Medicine for medical evaluation will have received a standard amount of carbohydrate intake for the three days prior to his arrival. This dietary preparation will be of benefit to each patient because it will reduce the amount of time which must be spent in dietary preparation and medical evaluation.

For the three days preceding your arrival at SAM for medical evaluation your diet should contain the following items in addition to any other foods you wish to eat:

Meat: any kind, at least two ounces once a day.

Potatoes: any kind, at least one serving of three ounces once a day.

Bread: any kind, two pieces three times a day.

Coffee with sugar: one cup once or twice a day.

If in-flight lunches are eaten be sure to add two five cent candy bars to each lunch.

Drink no alcohol during entire period of diet and fasting period.

Beginning at midnight of the night prior to first appointment DO NOT eat, drink or smoke.

You will be tested the morning of your arrival for sugar tolerance. Weight reducing diets or failure to comply with the above instructions can cause poor results in testing to the point that you might not be able to pass your medical evaluation. You are urged to follow the above instructions.

AEROMEDICAL SURVEY AND PHYSICAL EXAMINATION

Lawrence E. Lamb, M. D.

Granville J. Womack, Major, USAF, MC

Perry B. Miller, Major, USAF, MC

Robert L. Johnson, Lt. Col., USAF, MC

Each subject receiving an aeromedical evaluation receives a questionnaire to complete and return to the examining center prior to the date of evaluation. This extensive questionnaire was carefully designed by the combined staff of the Clinical Sciences Division of the USAF School of Aerospace Medicine. It encompasses all of the different specialties of medicine and includes in an objective fashion detailed information on the individual's past history, habits, and any symptomatology that he may have.

The questionnaire was specifically designed for use in the Air Force flying population. It has been in daily use within this laboratory for over two years. The flying population as a group have a relatively high IQ. Because of this most are quite adept at completing their own medical questionnaire in some detail.

The questionnaire provides a means for objective data retrieval and can automatically be precoded. In such a manner it may be used immediately for transfer to any forms of data systems for analysis, correlations, or automatic data handling and retrieval.

Such a formalized history provides for uniform information. It gives each subject an opportunity to weigh each question before answering it. This assures that significant information will not be quickly forgotten in a ra d-fire medical interview.

In addition to allowing time for reflection or verification of information such a complex medical survey makes certain that the medical examiner does not omit any important questions. Although it is a time-honored practice to extol the importance of medical history taking, regardless of the individual examining physician's training or skill, such history taking procedures are seldom complete. Most comments in reference to this area are primarily lip service. To accomplish an extensive medical history as encompassed within the scope of the forms included in this examination would require an oral interview between the examining physician and his subject of approximately six hours. It is most unusual for the physician of today to spend six hours questioning or interviewing his patient, regardless of the examining physician's skill or background.

The aeromedical survey as developed by the staff is not intended to supplant the physician's judgment or necessity in taking his own verbal history. It provides a supplement to insure completeness and to direct his attention to those areas which would appear to be most productive to probe more thoroughly in verbal interview.

The feasibility of using such a procedure has been established by its daily use within this laboratory. It has been tested out in excess of well over 1,000 subjects from different military installations throughout the world. Such a procedure has repeatedly proved its worth. It is particularly adaptable to a highly intelligent well-motivated population such as encountered in the Air Force flying group.

The cover sheet provides identification data and a place for indicating diagnoses. Each item on this form is also coded for data collection.

01 AEROMEDICAL SURVEY - IDENTIFICATION DATA

SOCIAL SECURITY NUMBER	NAME (Last, First, MI)	DATE OF BIRTH: MONTH	DAY	YEAR

RACE
- a ☐ CAUCASIAN
- b ☐ NEGROID
- c ☐ ASIAN
- d ☐ OTHER

AFSN

GRADE
- a ☐ CADET
- b ☐ 2 LT
- c ☐ 1 LT
- d ☐ CAPT
- e ☐ MAJ
- f ☐ LT COL
- g ☐ COL
- h ☐ BRIG GEN
- i ☐ MAJ GEN
- j ☐ LT GEN
- k ☐ GEN
- l ☐ OTHER

AGE

DATE OF QUESTIONNAIRE: MONTH	DAY	YEAR

HOME ADDRESS

MILITARY ADDRESS

MAJOR COMMAND

NAME, RELATIONSHIP, AND PERMANENT ADDRESS OF TWO (2) CIVILIANS THROUGH WHOM YOU MAY BE CONTACTED IN SUBSEQUENT YEARS.

PURPOSE OF EXAMINATION

FLYING PHYSICAL: a ☐ CLASS I b ☐ CLASS I A c ☐ CLASS II d ☐ CLASS III

e ☐ USAF ACADEMY f ☐ NON FLYING PHYSICAL g ☐ OTHER

TO BE COMPLETED BY PHYSICIAN

DIAGNOSIS

Continue on reverse if necessary

DATE OF EXAMINATION: MONTH	DAY	YEAR	TYPED OR PRINTED NAME OF EXAMINING PHYSICIAN

EXAMINING FACILITY

SIGNATURE

DO NOT WRITE IN THIS SPACE

02. NARRATIVE HISTORY

1 ☐ YES 2 ☐ NO

2a. ______
b. ______
c. ______
d. ______
e. ______
f. ______
g. ______
h. ______
i. ______
j. ______
k. ______
l. ______
m. ______
n. ______
o. ______

SAM HQ FORM FEB 63 0-18 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

02 AEROMEDICAL SURVEY – NARRATIVE HISTORY

SOCIAL SECURITY NUMBER	NAME (*Last, First, MI*)	DATE OF QUESTIONNAIRE		
		MONTH	DAY	YEAR

SUBJECT'S MEDICAL HISTORY: *(TYPE OR PRINT LEGIBLY IN BLACK INK OR PENCIL)*

In narrative fashion state why you are being evaluated, for example: "Annual Aeromedical Examination": "I had an electrocardiogram showing some findings", or "I have stomach ulcers", or "I have headaches", or "I had loss of consciousness". Give all the details that you can, including date of onset or discovery. If you are not entirely well, how do you feel badly? What factors make your symptoms occur? What makes your symptoms worse? What factors relieve your symptoms? If it is an event such as loss of consciousness, describe all the circumstances about the event you can recall. Give all details in chronological order.

continue on reverse side

SAM HQ FORM FEB 63 O–18a

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

AEROMEDICAL SURVEY BACKGROUND DATA

In evaluating the frequency of surgical procedures in 32 consecutive candidates there were only two subjects that had no history of any surgical procedure. The following is a list of the surgical procedures done in this group:

Tonsillectomy	26
Circumcision	22
Appendectomy	3
Hydrocele	1
Oral surgery (cyst removal)	1
Unilateral orchidectomy	1
Left knee cartilage removed	1
Submucous resection	1
Cyst and scar removal	1
Mastoidectomy	1
Double hernia	1
Vasectomy	1

Minor to moderately severe injuries are frequent in examinees of this category. In 32 consecutive subjects only six individuals recalled no injuries. The fractures sustained by this group are indicated below:

One extremity fracture (or clavicle)	7
Two extremities fractured	3
Three extremities fractured	1
Fractured nose (once)	2
Fractured nose (multiple)	1
Vertebral transverse process	1

In addition to the fractures noted there were multiplicities of other injuries including torn ligaments, cuts, bruises, dog bites, dislocations, sprains, and in one individual a head injury associated with an automobile accident resulting in loss of consciousness for a two-day period.

Civilian occupations covered a gamut of different interests by the subjects but since most of the candidates were military subjects the level of the civilian jobs held as a group was not particularly high. Five individuals indicated that they had never held a civilian job. The remainder of the individuals listed the following occupations:

Engineering test pilot	6
Test engineer	3
Newspaper boy	5
Store clerk	5
Odd jobs	5
Unskilled factory labor	3
Golf pro's assistant	1
Summer labor	3
Life guard	2
Flight line mechanic	1
Dishwasher and window washer	1
Farm work	3
Auto mechanic	1
Forestry	1
Salesman	1
Hod carrier	1
Commercial pilot and flight instructor	1
Stock boy	1
Truck loader	1
Chemistry lab assistant	1
Gas station attendant	1
Bacteriology laboratory assistant	1
Road surveyor	1

Most of the candidates had the opportunity for foreign travel. Only two individuals indicated that they had never traveled beyond the United States and only four individuals' foreign travels were limited to Mexico. The remainder of the candidates had traveled to the following countries:

Mexico	6
Scotland	3
Italy	11
France	14
Turkey	3
Greece	4
Spain	9
Cuba	6
Switzerland	1
Lebanon	2
China	1
Philippines	4
Guam	2
Haiti	2
Hawaii	4
Trinidad	1
England	7
Azores	1
Greenland	1
Holland	3
Belgium	2
Germany	6
Canada	1
Japan	8
Korea	1
Nassau	1
British West Indies	2
Hong Kong	4
Puerto Rico	1
Brazil	1
Bermuda	1
Ireland	1
Morocco	1
Libya	1
Luxembourg	1
Norway	1
Okinawa	2
Formosa	3

All space pilot candidates have college degrees. Many are graduates of military academies and all others hold degrees from civilian universities. Some subjects have masters degrees in aeronautical or electrical engineering.

Only seven candidates denied that they had ever been involved in legal action. Minor infractions appeared to be the rule, the vast majority of which are speeding offenses. In the vast majority of instances the legal offenses were indeed minor and rarely of more serious magnitude. Offenses listed include:

Failure to yield right of way	1
Failure to stop at stop sign	2
Speeding	16
Illegal parking	6
Two traffic violations	7
Three or more traffic violations	5
Driving without a license	1
Moving traffic violations	3
Other minor traffic violations	1
Disturbing the peace	1
Wreckless driving	1
Driving while intoxicated causing an accident	1
Illegally shooting birds in a field	1

03 AEROMEDICAL SURVEY – BACKGROUND DATA

SOCIAL SECURITY NUMBER	NAME *(Last, First, MI)*	DATE OF QUESTIONNAIRE		
		MONTH	DAY	YEAR

01. CHECK THE POPULATION CLASSIFICATION WHICH BEST DESCRIBES THE COMMUNITY IN WHICH THE MAJOR PART OF YOUR CHILDHOOD AND YOUTH WAS SPENT:

a. [ ] FARM OR RURAL
b. [ ] LESS THAN 500
c. [ ] 500 – 4,999
d. [ ] 5,000 – 49,999
e. [ ] 50,000 – 499,999
f. [ ] 500,000 OR OVER

02. CHECK THE BOX BELOW THE NUMBER WHICH INDICATES THE YEAR OF EDUCATIONAL LEVEL YOU HAVE ATTAINED:

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21 OR OVER

03. HAVE YOU EVER GRADUATED FROM:

a. HIGH SCHOOL? 1. [ ] YES 2. [ ] NO

b. COLLEGE? 1. [ ] YES 2. [ ] NO

04. HAVE YOU OBTAINED A:

a. MASTER'S DEGREE? 1. [ ] YES 2. [ ] NO

b. Ph. D. OR EQUIVALENT DEGREE? 1. [ ] YES 2. [ ] NO

05. HAVE YOU EVER BEEN INVOLVED WITH THE LAW:

a. INCLUDING TRAFFIC VIOLATIONS? 1. [ ] YES 2. [ ] NO

b. OTHER THAN MINOR TRAFFIC VIOLATION? 1. [ ] YES 2. [ ] NO

c. FOR DRIVING WHILE INTOXICATED? 1. [ ] YES 2. [ ] NO

06. CHECK THE TYPES OF CIVILIAN JOBS YOU HAVE HELD:

a. [ ] NONE
b. [ ] STENOGRAPHIC
c. [ ] SALES CLERK
d. [ ] SALESMAN
e. [ ] PROFESSIONAL *(Lawyer, Doctor, Teacher, Minister)*
f. [ ] ENGINEER
g. [ ] ARTS
h. [ ] ATHLETICS
i. [ ] ADMINISTRATION
j. [ ] SCIENTIST
k. [ ] TECHNICIAN
l. [ ] MECHANIC
m. [ ] FACTORY
n. [ ] LABORER
o. [ ] FARMER
p. [ ] DOMESTIC
q. [ ] ODD JOBS
r. [ ] OTHER

07. CHECK ALL THE FOLLOWING PLACES IN WHICH YOU HAVE BEEN DURING THE LAST FIVE YEARS:

a. [ ] CANADA
b. [ ] MEXICO
c. [ ] SOUTH AMERICA
d. [ ] CENTRAL AMERICA OR CARIBBEAN AREA
e. [ ] ASIA AND PACIFIC AREA *(Excluding USSR)*
f. [ ] HAWAII
g. [ ] EUROPE *(Excluding USSR)*
h. [ ] USSR
i. [ ] AFRICA
j. [ ] ALASKA

SAM HQ FORM FEB 63 O–18 b PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

08. LIST ALL THE OPERATIONS WHICH YOU HAVE HAD AND APPROXIMATE DATES:

OPERATION	DATE (year only)	LEAVE BLANK

09. LIST ALL SIGNIFICANT INJURIES *(wounds, burns, fractures, chemicals, radiation burn, electrical injury, sprains, dislocations, poisoning)* YOU HAVE HAD AND THEIR APPROXIMATE DATES:

INJURY	DATE (year only)	LEAVE BLANK

SAM HQ FORM FEB 63 O-18b PAGE 2

FAMILY HISTORY

The fathers of 26 candidates were living. Their ages were as follows:

51-55 years	4
56-60 years	8
61-65 years	10
66-70 years	2
71-75 years	1
76-80 years	1

The fathers of six candidates were deceased as indicated below from the following causes:

Tuberculosis	Age 60
Carcinoma of the prostate	Age 56
Carcinoma	Age 69
Coronary	Age 49
Stroke	Age 65
Automobile accident	Age 48

Sixteen of the fathers were college graduates. Eleven were high school graduates and the remaining five had graduated from grade school.

All the candidates' mothers were living and their ages were as follows:

51-55 years	7
56-60 years	13
61-65 years	5
66-70 years	7

Eight were college graduates while 19 graduated from high school and the remaining five completed the grade school education.

The parents were separated during the childhood of five of the candidates. The ages of the candidates at the time of separation were as follows:

6 years
8 years
8 years
11 years
12 years

It was interesting to note that in 28 of the 32 instances the candidates were the first-born male child and in 21 candidates they were the first-born sibling. There were three subjects that were the only child in the family.

Only four of the maternal grandfathers were living; 28 were deceased. The ages of the living or the approximate age at the time of death are listed below:

Age	Living	Deceased
<50	0	2
51-55	0	0
56-60	0	1
61-65	0	6
66-70	0	1
71-75	0	7
76-80	2	2
81-85	1	3
86-90	1	3
91-95	0	1
Unknown	0	2

Seven of the maternal grandmothers were living, the remaining 25 were deceased. Their ages were as follows:

Age	Living	Deceased
<50	0	3
51-55	0	1
56-60	0	1
61-65	0	2
66-70	0	2
71-75	1	3
76-80	1	4
81-85	0	5

86-90	2	0
91-95	1	1
Unknown	2	3

There were three living paternal grandfathers and 29 deceased.

Their ages were as follows:

Age	Living	Deceased
< 50	0	2
51-55	0	1
56-60	0	4
61-65	0	7
66-70	0	3
71-75	0	2
76-80	0	4
81-85	0	0
86-90	2	2
Unknown	1	4

There were five living paternal grandmothers and 27 deceased.

Their ages were as follows:

Age	Living	Deceased
< 50	0	0
51-55	0	2
56-60	0	1
61-65	0	1
66-70	0	3
71-75	0	1
76-80	1	7
81-85	1	4
86-90	1	4
91-95	0	1
Unknown	2	3

Only one of the candidates was single, the remainder were married. There were no divorces. The number of children born in each marriage is as follows:

No children	1
One child	4
Two children	12
Three children	8
Four children	5
Five children	0
Six children	1

One candidate, the father of two children, lost a child from a brain tumor.

Six of the candidates denied any history of family illnesses. Those disorders of family or near relatives given by the candidates are as follows:

Hay fever	7 candidates
Tuberculosis	2
Diabetes	6
Arthritis	5
Allergies	2
Hypertension	4
Nephritis	1
Stroke	6
Amputation of extremity	1
Cancer	11
Leukemia	1
Goiter	1
Heart attack	7
Asthma	1
Heart failure	1
Mental disorder	1
Nervous breakdown	3
Rheumatic fever	1

04 AEROMEDICAL SURVEY – FAMILY HISTORY

SOCIAL SECURITY NUMBER	NAME (Last, First, MI)	DATE OF QUESTIONNAIRE MONTH	DAY	YEAR

CHECK THE BOX BELOW THE NUMBER WHICH INDICATES THE YEAR OF EDUCATIONAL LEVEL ATTAINED BY YOUR PARENTS:

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21 OR OVER
01. FATHER																						
02. MOTHER																						

03. CHECK THE ONE CORRECT STATEMENT WHICH APPLIES TO YOUR PARENTS:

1 ☐ NEVER SEPARATED OR DIVORCED
2 ☐ SEPARATED OR DIVORCED BEFORE YOU WERE 7 YEARS OF AGE.
3 ☐ SEPARATED OR DIVORCED WHEN YOU WERE BETWEEN 7 AND 15 YEARS OF AGE.
4 ☐ SEPARATED OR DIVORCED WHEN YOU WERE PAST 15 YEARS OF AGE.

04. HAS ANY MEMBER OF YOUR IMMEDIATE FAMILY BEEN INVOLVED WITH THE LAW?

1 ☐ YES 2 ☐ NO

05. FAMILY VITAL STATISTICS – Enter the number of living and deceased relatives in appropriate line and column. If you have none of a given relative (columns g through j), enter a zero on lines 1 and 2 for the column. If you do not know the number of a given relative, enter an X on line 3.
Give age at last birthday if living and age at death if deceased. If exact age is not known but approximate age is known, give approximate age. If you have no knowledge of age, enter XX.

	a FATHER	b MOTHER	c PATERNAL GRAND-FATHER	d PATERNAL GRAND-MOTHER	e MATERNAL GRAND-FATHER	f MATERNAL GRAND-MOTHER	g PAT-ERNAL UNCLE	h PAT-ERNAL AUNT	i MAT-ERNAL UNCLE	j MAT-ERNAL AUNT
1. LIVING										
2. DECEASED										
3. UNKNOWN										
4. AGE										

06. SIBLINGS – Designate in the order of birth, yourself, your brothers and sisters by placing an X in the appropriate column. Indicate whether each brother or sister is living or dead. Give you age and that of each sibling in the manner of 05 above. Indicate marital status of each sibling (yourself included) whether living or dead.

BIRTH ORDER	a MYSELF	b FULL BROTHER	c FULL SISTER	d HALF BROTHER	e HALF SISTER	f LIVING	g DEAD	h AGE	i SINGLE	j MARRIED	k SEPA-RATED	l SEPARATED AND REMARRIED	m WIDOW OR WIDOWER	n WIDOW OR WIDOWER & REMARRIED
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														

07. CHILDREN – Place an X in the appropriate boxes to indicate your children by order of birth. Give age at time of death if deceased. If you have no children and have not adopted any, check here [ ] and leave the rest of this section blank.

BIRTH ORDER	a YOURS	b ADOPTED	c MALE	d FEMALE	e LIVING	f DEAD	g AGE
1							
2							
3							
4							
5							
6							
7							
8							

SAM HQ FORM FEB 63 O-18c PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

08. FAMILY ILLNESSES – By placing the correct number in the appropriate column, indicate the number of living and deceased relatives who have or have had each disease condition listed on lines 01 thru 33. FOR EXAMPLE, if there are 3 diabetics in the family, a deceased paternal aunt and 2 brothers, entries on line 3 would be 1 in column h and 2 in column k. Each family member will be counted at least once for entries 01 thru 33. Lines 34 thru 40, OTHER *(specify)* – If some illnesses not listed are prevalent in your family, state illnesses and give the number of relatives so affected.

	a Father	b Mother	c Paternal Grandfather	d Paternal Grandmother	e Maternal Grandfather	f Maternal Grandmother	g Paternal Uncle	h Paternal Aunt	i Maternal Uncle	j Maternal Aunt	k Brothers	l Sisters	m Half Brothers	n Half Sisters
01. HEALTH HISTORY UNKNOWN														
02. NO SIGNIFICANT ILLNESS														
03. DIABETES														
04. MIGRAINE *(sick headache)*														
05. CONVULSIONS														
06. CANCER														
07. DISEASES OF BRAIN OR NERVOUS SYSTEM														
08. LEUKEMIA														
09. NERVOUS BREAKDOWN														
10. GOITER														
11. MENTAL DISORDER														
12. ASTHMA														
13. COMMITTED SUICIDE														
14. HAY FEVER														
15. ALLERGIES														
16. WASTING OR WEAKNESS OF SOME OF THEIR MUSCLES														
17. ANEMIA														
18. BLEEDING DISEASE														
19. SYPHILIS														
20. RHEUMATIC FEVER														
21. TUMORS														
22. TUBERCULOSIS														
23. HIGH BLOOD PRESSURE														
24. HEART MURMUR														
25. HEART DISEASE														
26. HEART ATTACK														
27. STROKE														
28. ARTHRITIS														
29. AMPUTATION OF LIMB														
30. HEART FAILURE														
31. PARALYSIS OF LIMB														
32. NEPHRITIS *(Bright's disease)*														
33. GOUT														
34. OTHER *(specify)*														
35. OTHER *(specify)*														
36. OTHER *(specify)*														
37. OTHER *(specify)*														
38. OTHER *(specify)*														
39. OTHER *(specify)*														
40. OTHER *(specify)*														

MILITARY AND AVIATION HISTORY

The 32 consecutive subjects analyzed in this detailed breakdown included six civilians, nine USAF test Pilots, 13 Navy test pilots, and four Marine test pilots. The six civilian individuals flew as pilot officers in the military services. The test pilot experience and training of the civilian candidates was a result of military services. Their length of military service was as follows:

3 years	1 candidate
3 1/2 years	1 candidate
4 years	4 candidates

Four of the civilians continued to fly in active reserve components of their respective services. The military and flying experience of the group is detailed in Table I. Most of the candidates had from six to ten years of flying experience which included one to six years of test pilot experience.

The total number of flying hours for individuals in the group ranged from 2,100 to 4,500 hours including military and civilian flying with an average of 2,913 hours of total flying time. Four of the individuals flew fighters in combat during the Korean conflict.

With the large amount of accumulated in-flight time, a number of in-flight incidents would be expected. These are as follows:

Number of Accidents	Number of Subjects
None	15
One minor accident	4
One major accident	8
One major, one minor accident	1
One major, two minor accidents	1
Two major, one minor accidents	1
Three major accidents	2

In all of these accidents, with one exception, the individual was in primary control of the aircraft at the time of the accident. The exception was one individual's only experience as a passenger in a major landing accident. None of the individuals suffered significant injury. Related to the accidents, five individuals made successful ejections from crippled aircraft and one bailed out successfully. The reasons for the emergency escapes included mid-air collision, in-flight fire, and one loss of control due to systems malfunction.

Table I

Military and flying experience by number of candidates

Years	Number of Subjects			
	Active duty*	Commissioned*	Pilot-rated	Test pilot
1				3
2				7
3				6
4				4
5				7
6			2	3
7		1	2	1
8	1	3	9	1
9	1	6	9	
10	4	10	4	
11	3	0	2	
12	3	4	2	
13	2	1	0	
14	6	1	2	
15	1			
16	4			
17	1			
Total	26	26	32	32

* Civilian candidates not enumerated here.

06 AEROMEDICAL SURVEY – MILITARY AND AVIATION HISTORY

SOCIAL SECURITY NUMBER	NAME (*Last, First, MI*)	DATE OF QUESTIONNAIRE		
		MONTH	DAY	YEAR

01. Designate service and status by placing X in appropriate box.

SERVICE	a REGULAR	b RESERVE	c NATIONAL GUARD	d ENLISTED	e CADET	f OTHER
1. USAF						
2. ARMY						
3. NAVY						
4. NONE – CIVILIAN ☐						

02. At present I am a cadet, training to rating as:
a ☐ PILOT
b ☐ OBSERVER
c ☐ OTHER

03. Total active service

	a YEARS	b MONTHS
1. TOTAL ACTIVE DUTY		
2. COMMISSIONED OFFICER		
3. RATED (*flying*)		

04. Military flying qualification

RATING	DATE QUALIFIED MONTH	YEAR
1. PILOT		
2. SR PILOT		
3. COMMAND PILOT		
4. NAVIGATOR		
5. SR NAVIGATOR		
6. MASTER NAVIGATOR		
7. FLIGHT SURGEON		
8. JET QUAL.		

05. Hours flown in military aircraft

TYPE AIRCRAFT	a PILOT	b CO-PILOT	c OBSERVER	d OTHER	e TOTAL
1. SINGLE ENGINE RECIP					
2. MULTIPLE ENGINE RECIP					
3. SINGLE ENGINE JET					
4. MULTIPLE ENGINE JET					

06. At present flying ______________ type of aircraft as ______________ and have logged ______________ hours in the past six months.

07. Are you on flying status? 1 ☐ YES 2 ☐ NO Date last met flight requirements (*month & year*) ______________

08. Have you flown in combat? 1 ☐ YES 2 ☐ NO

a WORLD WAR II		b KOREA		c OTHER (*specify*)	
NR MISSIONS	NR HOURS	NR MISSIONS	NR HOURS	NR MISSIONS	NR HOURS

09. Number of hours you have flown with aircraft altitude greater than:

a. 20,000 FEET	b. 30,000 FEET	c. 40,000 FEET	d. 50,000 FEET	e. 60,000 FT OR OVER

10. Number of parachute jumps (*Circle one*)
00 01 02 03 04 05 06 07 08 09 10

11. Nr of balloon flights	12. Nr of balloon hours	13. Number of balloon hours at an altitude above: a. 50,000 FEET	b. 75,000 FEET	c. 100,000 FEET

14. Have you had partial pressure suit indoctrination?
a. USAF 1 ☐ YES 2 ☐ NO
b. USN 1 ☐ YES 2 ☐ NO
c. OTHER 1 ☐ YES 2 ☐ NO

15. Total number of hours you have worn a partial pressure suit (*record 0000 if you have not*)

16. Have you operated an altitude suit during flight? 1 ☐ YES ____ HRS 2 ☐ NO 0000 HRS

17. Have you had experience with:
a. USAF FULL PRESSURE SUIT 1 ☐ YES 2 ☐ NO
b. USN FULL PRESSURE SUIT 1 ☐ YES 2 ☐ NO

18. Have you used full pressure suit in flight? 1 ☐ YES ____ HRS 2 ☐ NO 0000 HRS

19. Have you had upward ejection seat training? 1 ☐ YES 2 ☐ NO

20. Have you had downward ejection seat training? 1 ☐ YES 2 ☐ NO

21. Have you used ejection seat in flight? 1 ☐ YES (*number*) ____ TIMES 2 ☐ NO 00 TIMES

22. Have you had decompressions in flight? 1 ☐ YES a ☐ GRADUAL b ☐ EXPLOSIVE 2 ☐ NO

DESCRIBE (*including dates*)

SAM HQ FORM FEB 63 O-18e REPLACES SAM HQ FORM O-18D WHICH IS OBSOLETE.

23. Have you been involved in any aircraft accidents? 1 [ ] YES 2 [ ] NO *(If yes, give details)*

24. Have you been injured in any aircraft accident? 1 [ ] YES 2 [ ] NO *(If yes, give details)*

25. Total number of Ascents in a Low Pressure Chamber	26. Date of last Chamber Flight		27. Total number of Rapid Decompressions in Low Pressure Chambers	28. Date of last Decompression	
	MONTH	YEAR		MONTH	YEAR

29. In the low pressure chamber, have you had symptoms? 1 [ ] YES 2 [ ] NO

(If yes, at what altitudes?)

30. Have you had any symptoms during rapid decompression? 1 [ ] YES 2 [ ] NO

If the answer is YES to either question 29 or 30, describe (including dates):

31. Have you been a prisoner of war? 1 [ ] YES 2 [ ] NO *(If yes, list dates and theater of service when imprisoned)*

32. Did you have any significant illnesses or injuries as a prisoner of war? 1 [ ] YES 2 [ ] NO

(If yes, describe circumstances)

33. Do you have flight pay insurance?

1 [ ] YES 2 [ ] NO

34. Have you had civilian pilot experience?

1 [ ] YES 2 [ ] NO

35. Civilian Pilot Experience *(If applicable)*

TYPE AIRCRAFT	TOTAL HOURS
1. SINGLE-ENGINE – LAND	
2. MULTIENGINE – LAND	
3. SINGLE-ENGINE – WATER	
4. MULTIENGINE – WATER	
5. HELICOPTER	
6. OTHER	

36. Civilian Licenses and Rating:

1. [ ] STUDENT
2. [ ] PRIVATE
3. [ ] COMMERCIAL
4. [ ] ATR
5. [ ] INSTRUCTOR
6. [ ] OTHER

SAM HQ FORM FEB 63 O–18c PAGE 2

HABITS

Twelve of the candidates did not use tobacco in any form; of these, 11 had never smoked and the twelfth individual smoked for six months in his late teens. The remaining 20 used tobacco in one form or another. Ten of these consumed cigarettes only varying from 40 to 10 cigarettes a day with an average in amount of 20 cigarettes per day. Two individuals smoked cigars only, eight per month for one individual and one to two per day for the other.

Two individuals smoked two to three cigars and a pack of cigarettes daily. Two persons smoked cigarettes and pipes; one smoked one-quarter pack of cigarettes and four pipes daily, and the other, one-half pack of cigarettes and two pipes daily. Two individuals smoked pipes and cigars; one of them smoked two to three pipes and an occasional cigar daily, and the other, two pipes in addition to two to three cigars weekly. There were two persons who smoked pipes, cigars and cigarettes, consuming about one pack of cigarettes daily with two to three cigars weekly and at least six pipes daily. There were no individuals who used pipes exclusively.

None of the individuals used drugs, vitamins, or nasal inhalers regularly or even occasionally. All had used these items rarely as a prescription for acute illnesses.

The sleeping habits indicated that 27 individuals slept between six and eight hours nightly while the remaining five slept between eight and nine hours regularly.

The exercise habits of these individuals were quite varied. As a group, however, they were athletically inclined and enjoyed physical recreation. Twenty-one of the individuals had a regular planned exercise program while 11 did not. Frequency of their exercise program is indicated as follows:

Daily	18 candidates
Two to three times per week	4 candidates
Once a week	9 candidates
Less than once a week	1 candidate

One of the individual's breakfast consisted usually of coffee and a roll. All of the other candidates ate three regular meals a day with a heavy all-American breakfast, generally a light lunch, and a fairly heavy dinner. Eight persons occasionally snacked between meals.

Only four of the individuals abstained from coffee. The amount of coffee drunk daily by individuals is as follows:

Cups of Coffee	Candidates
0	4
1-2	10
3-6	17
7-10	1

There were four individuals who did not drink milk. The average daily milk consumption was as follows:

None	4 candidates
0-1/2 quart	22 candidates
1/2-1 quart	5 candidates
Over 1 quart	1 candidate

Only one individual was a total abstainer from alcohol. Frequency and amount of alcoholic intake was as follows:

None	1 candidate
Rarely	5 candidates
Socially (less than one drink daily)	14 candidates
Average one drink daily	12 candidates

Included in the cocktail habits, individuals would occasionally drink three to four drinks at a social gathering but averaged either one cocktail a day or less than one daily. There was no history of repeated or recurrent frequency of excessive alcoholic ingestion.

Only one of the individuals appeared to have a major weight problem. There were 24 individuals who had never weighed more than 10 pounds above their body weight at age 25. The remaining eight individuals had weighed 10 pounds or more above their body weight at age 25.

05 AEROMEDICAL SURVEY – HABITS

SOCIAL SECURITY NUMBER	NAME *(Last, First, MI)*	DATE OF QUESTIONNAIRE MONTH / DAY / YEAR

01. HOW MANY HOURS DO YOU WORK A DAY?

02. HOW MANY MONTHS HAVE PASSED SINCE YOU LAST HAD A VACATION OF TWO WEEKS OR MORE?

03. HOW OFTEN DO YOU NOW ENGAGE IN PLANNED EXERCISE FOR PHYSICAL FITNESS OR IN PHYSICAL RECREATIONAL ACTIVITIES *(tennis, swimming, handball, etc.)*?
1. ☐ NOT AT ALL 2. ☐ LESS THAN ONCE A WEEK 3. ☐ 2 – 4 DAYS A WEEK
4. ☐ ONCE A WEEK 5. ☐ DAILY

04. DO YOU REGULARLY PARTICIPATE IN COMPETITIVE SPORTS?
1. ☐ YES 2. ☐ NO

05. DID YOU PARTICIPATE REGULARLY IN ORGANIZED SPORTS IN HIGH SCHOOL *(other than required physical education classes)*?
1. ☐ YES 2. ☐ NO

06. DID YOU PARTICIPATE REGULARLY IN ORGANIZED SPORTS IN COLLEGE? *(check one)*
1. ☐ YES 2. ☐ NO 3. ☐ DID NOT ATTEND COLLEGE

07. HAVE YOU EVER PARTICIPATED IN PROFESSIONAL ATHLETICS?
1. ☐ YES 2. ☐ NO

08. HAVE YOU BEEN A PLAYING MEMBER OF A COLLEGE OR AMATEUR ATHLETIC TEAM FOR NATIONAL OR INTERNATIONAL ATHLETIC EVENTS?
1. ☐ YES 2. ☐ NO

09. HOW MANY HOURS IS YOUR AVERAGE SLEEP EACH NIGHT?

10. DO YOU SLEEP SOUNDLY THROUGHOUT THE SLEEP PERIOD?
1. ☐ YES 2. ☐ NO

11. ARE THERE ANY DRUGS OR MEDICINE INCLUDING ASPIRIN WHICH YOU TAKE FREQUENTLY?
1. ☐ YES 2. ☐ NO

	1 YES	2 OCCASIONALLY	3 NO
12. HAVE YOU EVER TAKEN HORMONES *(thyroid or other)* WITH OR WITHOUT A DOCTOR'S PRESCRIPTION?			
13. DO YOU TAKE VITAMINS?			
14. DO YOU TAKE SLEEPING PILLS?			
15. DO YOU TAKE TRANQUILIZERS?			
16. DO YOU TAKE PEP PILLS, BENZEDRINE OR DEXEDRINE?			
17. DO YOU USE A NASAL INHALER?			

18. WHAT IS YOUR APPROXIMATE HEIGHT TO THE NEAREST INCH?

19. HOW MUCH DID YOU WEIGH AT AGE 20? *(If not yet 20 record XX)*

20. HOW MUCH DID YOU WEIGH AT AGE 25? *(If not yet 25 record XX)*

21. WHAT IS THE LEAST YOU HAVE WEIGHED SINCE AGE 25? *(If not yet 25 record XX)*

22. WHAT IS THE MOST YOU HAVE WEIGHED SINCE AGE 25? *(If not yet 25 record XX)*

23. HAVE YOU GAINED WEIGHT IN THE LAST 2 YEARS?
1. ☐ YES ______ LBS. 2. ☐ NO 00 LBS.

24. HAVE YOU LOST WEIGHT IN THE LAST 2 YEARS?
1. ☐ YES ______ LBS. 2. ☐ NO 00 LBS.

	1 YES	2 NO
25. HAVE YOU HAD A WEIGHT GAIN OF 10 POUNDS OR MORE IN THE LAST SIX MONTHS?		
26. HAVE YOU HAD A WEIGHT LOSS OF 10 POUNDS OR MORE IN THE LAST SIX MONTHS?		
27. HAVE YOU EVER DIETED TO LOSE WEIGHT?		
28. HAVE YOU EVER TAKEN MEDICINE OR PILLS TO HELP YOU LOSE WEIGHT?		

29. HAVE YOU EVER REGULARLY SMOKED CIGARETTES?
1. ☐ YES 2. ☐ NO

30. HAVE YOU EVER REGULARLY SMOKED CIGARS?
1. ☐ YES 2. ☐ NO

31. HAVE YOU EVER REGULARLY SMOKED A PIPE?
1. ☐ YES 2. ☐ NO

32. IF YOU NOW SMOKE CIGARETTES INDICATE THE NUMBER PER DAY *(If you do not smoke cigarettes record 00)*.

33. IF YOU NOW SMOKE CIGARS INDICATE THE NUMBER PER DAY *(If you do not smoke cigars record 00)*.

34. IF YOU NOW SMOKE A PIPE INDICATE THE NUMBER OF PIPESFUL PER DAY *(If you do not smoke a pipe record 00)*

35. GIVE THE AGE WHEN YOU BEGAN REGULARLY SMOKING CIGARETTES *(If you have not smoked record XX)*

36. GIVE THE AGE WHEN YOU BEGAN REGULARLY SMOKING CIGARS *(If you have not smoked record XX)*

37. GIVE THE AGE WHEN YOU BEGAN REGULARLY SMOKING A PIPE *(If you have not smoked record XX)*

	1 NEVER SMOKED	2 NO	3 YES, AT AGE	4 AVERAGE NUMBER SMOKED PER DAY BEFORE QUITTING
38. HAVE YOU QUIT SMOKING CIGARETTES?				
39. HAVE YOU QUIT SMOKING CIGARS?				
40. HAVE YOU QUIT SMOKING PIPES?				

SAM HQ FORM FEB 63 O-18d REPLACES SAM HQ FORM O-18E WHICH IS OBSOLETE.

41. DO YOU USE CHEWING TOBACCO?

1 [ ] YES   2 [ ] NO

42. DO YOU USE SNUFF?

1 [ ] YES   2 [ ] NO

43. HOW MANY CUPS OF COFFEE DO YOU DRINK A DAY? *(check one answer only)*

a [ ] NONE
b [ ] LESS THAN ONE
c [ ] ONE
d [ ] 2 TO 4
e [ ] 5 TO 8
f [ ] 9 TO 12
g [ ] 13 OR MORE

44. HOW MANY CUPS OF TEA DO YOU DRINK A DAY? *(check one answer only)*

a [ ] NONE
b [ ] LESS THAN ONE
c [ ] ONE
d [ ] 2 TO 4
e [ ] 5 TO 8
f [ ] 9 TO 12
g [ ] 13 OR MORE

45. IN WARM WEATHER HOW MUCH ICED TEA DO YOU DRINK A DAY? *(check one answer only)*

a [ ] NONE
b [ ] LESS THAN ONE GLASS
c [ ] ONE GLASS
d [ ] 2 TO 4 GLASSES
e [ ] 5 OR MORE GLASSES

46. HOW MUCH MILK DO YOU DRINK A DAY? *(check one answer only)*

a [ ] NONE
b [ ] LESS THAN ONE GLASS
c [ ] ONE GLASS
d [ ] TWO GLASSES
e [ ] 3 TO 4 GLASSES
f [ ] 5 TO 6 GLASSES
g [ ] 7 OR MORE GLASSES

47. DO YOU DRINK ALCOHOLIC BEVERAGES?

a [ ] SOCIALLY
b [ ] ALMOST EVERY DAY
c [ ] RARELY
d [ ] NEVER

48. HOW MUCH HARD LIQUOR DO YOU DRINK? *(Complete one answer only — if none, record 00)*

a ______ NONE
b ______ OZ. PER DAY
c ______ OZ. PER WEEK
d ______ OZ. PER MONTH
e ______ OZ. PER YEAR

49. HOW MUCH BEER DO YOU DRINK? *(Complete one answer only — if none, record 00)*

a ______ NONE
b ______ GLASSES PER DAY
c ______ GLASSES PER WEEK
d ______ GLASSES PER MONTH
e ______ GLASSES PER YEAR

50. HOW MUCH WINE DO YOU DRINK? *(Complete one answer only — if none, record 00)*

a ______ NONE
b ______ GLASSES PER DAY
c ______ GLASSES PER WEEK
d ______ GLASSES PER MONTH
e ______ GLASSES PER YEAR

51. COMPLETE THE APPROPRIATE SPACES TO DESCRIBE THE NUMBER OF TIMES YOU ARE INTOXICATED:

a [ ] NEVER   b [ ] VERY RARELY   c AVERAGE *(number)* ________ TIMES PER { 1 [ ] WEEK 2 [ ] MONTH 3 [ ] YEAR }

	1 YES	2 NO
52. DO YOU EVER DRINK ALONE?		
53. DO YOU DRINK IN THE MORNING?		
54. DO YOU DRINK AT LUNCH?		
55. DO YOU DRINK OFTEN BEFORE THE EVENING MEAL?		

	1 YES	2 OCCASIONALLY	3 NO
56. DO YOU EAT BETWEEN MEALS?			
57. DO YOU EAT A BEDTIME OR NIGHT TIME SNACK?			

58. CHECK EACH ITEM *(or type)* OF FOOD YOU USUALLY EAT FOR BREAKFAST:

a [ ] NOTHING
b [ ] FRUIT, FRUIT JUICE OR TOMATO JUICE
c [ ] TOAST
d [ ] CEREAL
e [ ] EGGS
f [ ] BACON, HAM OR SAUSAGE
g [ ] PANCAKES OR WAFFLES
h [ ] SWEET ROLL, DOUGHNUT, COFFEE CAKE OR DANISH PASTRY
i [ ] COFFEE
i [ ] OTHER

59. CHECK EACH FOOD ITEM THAT IS PART OF YOUR USUAL LUNCH:

a [ ] SALAD
b [ ] MEAT
c [ ] VEGETABLES OTHER THAN POTATOES
d [ ] POTATOES
e [ ] SOUP
f [ ] BREAD, ROLLS, BISCUIT
g [ ] SANDWICHES
h [ ] DESSERT - PIE, CAKE, PUDDING, ICE CREAM
i [ ] FRUIT
j [ ] CHEESE
k [ ] EGGS

60. CHECK EACH FOOD ITEM THAT IS PART OF YOUR USUAL DINNER:

a [ ] SALAD
b [ ] MEAT
c [ ] VEGETABLES OTHER THAN POTATOES
d [ ] POTATOES
e [ ] SOUP
f [ ] BREAD, ROLLS, BISCUIT
g [ ] DESSERT - PIE, CAKE, PUDDING, ICE CREAM
h [ ] FRUIT
i [ ] CHEESE
j [ ] EGGS

SYSTEM REVIEW

The system review consists of 587 questions which can be answered "yes" or "no." They cover the entire gamut of symptoms, past illnesses, injuries and significant complaints which might be presented by a variety of medical defects. The number of candidates giving a significant reply to each question is given in the "yes" column following each question. In this manner the reader may have direct reference to the number of candidates giving a significant reply to any specific query.

The usual childhood diseases were common. Four of the candidates had experienced episodes of aero-otitis media as a result of flying with a cold.

Two individuals had mild allergies during childhood and one candidate had a brief episode labeled as allergic rhinitis during his adult life as a single isolated episode.

The majority of the individuals had episodes of spatial disorientation or "aviator's vertigo" while flying under the hood or in instrument weather. One individual reported episodes of car sickness as a child and five had transitory air sickness in early pilot training.

Six candidates had eleven episodes of near loss or actual loss of consciousness. In three individuals this was associated with trauma during athletics. One candidate had unconsciousness associated with severe trauma as a result of an automobile accident. The period of unconsciousness was for two days associated with complete amnesia for the events surrounding the accident. There was no skull fracture. Other syncopal episodes were associated with venipunctures and vaccinations, usually below the age of 20. Only one candidate had recurring syncopal symptoms of varying degree with almost every experience involving venipuncture.

One individual had constitutional hyperbilirubinemia as a benign condition. Four other candidates had had episodes of nonspecific urethritis; one of these had an acute urinary tract infection, by history, involving the kidneys.

All the candidates have been exposed to the hazards of increased noise fields associated with flying operations and have been exposed to potentially toxic fuels and radioactive materials as a part of their normal performance duty. A breakdown of the positive responses are included in the attached format of the system review.

07 AEROMEDICAL SURVEY – SYSTEM REVIEW

SOCIAL SECURITY NUMBER	NAME *(Last, First, MI)*	DATE OF QUESTIONNAIRE MONTH	DAY	YEAR

I DEVELOPMENTAL HISTORY *(Check Yes or No)*	1 YES	2 NO	
Were you a full term baby?	2		001
Did you have any abnormalities at birth?			002
Were there any birth injuries?			003
Were you told that you were a blue baby?			004
As an infant were you a feeding problem?			005
Did you have a problem with bed wetting?			006
Did you have a childhood habit of thumb sucking?	2		007
Did you stammer or stutter?			008
Were you left handed?	3		009
Are you now left handed?	3		010
Did you have trouble being taught to write?			011
Did you have temper tantrums?			012
Did you have sleep walking?	1		013
Did you have any special fears as a child?			014
Did you have a congenital *(present at birth)* defect of your heart?			015
Did you have any other congenital defect?			016
Did you have cyanosis or bluish discoloration at birth or in infancy?			017
Did you have any large birthmarks?			018

II. HAVE YOU HAD ANY OF THE FOLLOWING ILLNESSES? *(Check Yes or No)*	1 YES	2 NO	
Whooping Cough	16		019
Mumps	27		020
Measles	30		021
Chickenpox	26		022
Pellagra			023
Epidemic Hemorrhagic Fever			024
Psittacosis "Parrot Fever"			025
Yellow Fever			026
Dengue			027
Infectious Mononucleosis	2		028
Typhus			029
Rocky Mountain Spotted Fever			030
Q Fever			031
Diphtheria			032
Cholera			033
Brucellosis *(Malta Fever)*			034
Tuberculosis			035
Plague			036
Tularemia			037
Meningitis			038
Smallpox			039
Herpes, "Shingles"			040
Tetanus			041
Encephalitis *(Brain Fever)*			042
Scarlet Fever	5		043
Erysipelas			044
Inflammatory Rheumatism			045
Rheumatic Fever			046
St. Vitus Dance			047

II. (Cont'd) HAVE YOU HAD ANY OF THE FOLLOWING ILLNESSES? *(Check Yes or No)*	1 YES	2 NO	
Trichinosis			048
Typhoid Fever			049
Paratyphoid Fever			050
Bacillary Dysentery			051
Poliomyelitis			052
Trachoma			053
Relapsing Fever			054
Rat-Bite Fever *(Weils' disease)*			055
Maduromycosis			056
Histoplasmosis			057
Coccidioidomycosis			058
Blastomycosis			059
Actinomycosis			060
Pneumonia	7		061
Coxsackie			062
A venereal disease			063
Gonorrhea			064
Syphilis			065
Lymphogranuloma			066
Granuloma Inguinale			067
Yaws			068
Cat Scratch Disease			069
Osteomyelitis			070
Hook Worms	1		071
Round Worms	1		072
Pin Worms	2		073
Fluke Infections			074
Malaria			075
Amebic Abscess			076
Amebic Dysentery			077
Amebiasis			078
Sinusitis	4		079
Frequent Colds			080
Peritonsillar Abscess			081
Acute Tonsillitis and Pharyngitis			082
Quinsy			083
Laryngitis	5		084
Strep Throat			085
Otitis Media			086
Abscessed Ear	1		087
Mastoiditis	1		088
Influenza	10		089
Fever of Unknown Origin			090
Ulcers			091
Bronchitis	4		092
Bronchiectasis	1		093
A cancer or malignancy			094
Pyelitis	1		095
Eczema or psoriasis			096
Glaucoma			097
Bursitis			098
Bronchial Asthma	1		099

SAM HQ FORM FEB 63 0–18f PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE. PAGE 1 OF 7 PAGES

II. (Cont'd) HAVE YOU HAD ANY OF THE FOLLOWING ILLNESSES? *(Check Yes or No)*	1 YES	2 NO	
Pleurisy			100
Anemia			101
Arthritis			102
Gangrene			103
Pleurodynia			104
Devil's Grip			105
Hay Fever	2		106
Asthma			107
Jaundice			108
Hepatitis			109
Cirrhosis			110
Liver disease	1		111
Gallbladder disease or gallstones			112
Pericarditis *(Inflammation of the sac around the heart)*			113
A stroke			114
Migraine headaches			115
Contact dermatitis	1		116
Serum sickness			117
Giant hives			118
Heat prostration or sunstroke			119
Growing Pains	2		120

III. WHICH OF THE FOLLOWING DESCRIBE YOUR HABITS OR CHARACTERISTICS *(Check Yes or No)*	1 YES	2 NO	
Easily excited			121
Tense and anxious			122
Touchy or irritable	1		123
Orderly, precise and perfectionistic	6		124
Feelings easily hurt	1		125
Dissatisfied with present duties	1		126
Dissatisfied with your relationship with your wife			127
Awaken early in the morning before it is time to get up			128
Unhappy and depressed			129
Occassionally cry			130
Eat rapidly	5		131
Eat between meals	12		132
Easily upset by criticism			133
Use A.P.C.'s frequently			134
Use bromides frequently			135
Take Tums or other medication for burning or acid stomach	1		136
Take enemas			137
Take laxatives			138
Frequent difficulty in falling asleep			139
Difficulty making up your mind			140
Worry or sleep poorly before flights			141
Often feel guilty or inadequate			142
Drink more alcohol than is good for you			143
Do you feel that your superiors are unfair toward you	7		144
Worried about your health			145
Panic if closed up in a small room			146

IV. HAVE YOU EVER HAD ANY ILL EFFECTS FROM *(Check Yes or No)*	1 YES	2 NO	
Penicillin?			147
A.P.C.'s?			148
Sulfa drugs ?	1		149

IV. (Cont'd) HAVE YOU EVER HAD ANY ILL EFFECTS FROM *(Check Yes or No)*	1 YES	2 NO	
Quinine ?			150
Quinidine ?			151
Primaquine ?			152
Any drug given for malaria?			153
Benzedrine?			154

V. HAVE YOU EVER OR HAVE YOU EVER BEEN *(Check Yes or No)*	1 YES	2 NO	
Exposed to high intensity noise?	25		155
Used protective devices against noise such as ear plugs or ear defenders?	20		156
Failed a vision or eye test?			157
Worn contact lenses?			158
Lost control of your bowels?			159
Circumcised?	22		160
Lost control of your muscles or have your knees buckle momentarily during periods of emotion such as laughter or anger?			161
Employed as a metal worker, welder or pipefitter?			162
Employed in handling materials used for detonation of explosives?			163
Employed in making thermometers, extraction of gold or silver by chemical process, or been employed in putting on antifouling plastic paint on the hulls of warships or other vessels?	1		164
Poisoned by ingestion of mercury or mercury products?			165
Exposed to beryllium containing fumes or dust?			166
Employed as a painter?	2		167
Employed or worked with the manufacture of rubber goods or patent and artificial leather?			168
Exposed to Benzene?			169
Worked in filling or emptying a farm silo?	5		170
Frequently exposed to increased quantities of carbon monoxide?			171
Exposed to lead such as leaded fuel and lead base paints?	8		172
Exposed to Arsine?			173
Engaged in aerial spraying or crop-dusting?			174
Exposed to trinitrotoluene?			175
Exposed to unsymmetrical dimethyl hydrazine (UDMH)?			176
Received radium treatment for any reason			177
Exposed to other than diagnostic x-rays, exposed to radiation or radiation therapy?	5		178
Drunk bad alcoholic beverages such as "rot gut" whiskey or bootleg products or wood alcohol?	1		179
Taken antihistimines?	19		180
Felt that you have been a failure in life?			181
Seriously considered committing suicide?			182

VI. DO YOU HAVE, HAVE YOU HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD (Check Yes or No)	1 YES	2 NO	
Fainting or loss of consciousness?	3		183
Dizzy spells ?			184
A convulsion ?			185
Unusual fatigue ?			186
Fatigue when you awake in the morning?			187
Fatigue in the early afternoon?			188
An unusual amount of thirst?			189

SAM HQ FORM FEB 63 O-18f

07 AEROMEDICAL SURVEY – SYSTEM REVIEW (Continued)

SOCIAL SECURITY NUMBER	NAME (Last, First, MI)	DATE OF QUESTIONNAIRE MONTH	DAY	YEAR

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD (Check Yes or No)	1 YES	2 NO	
Unusual intolerance to cold weather?			190
Unusual intolerance to hot weather?			191
A change in hair texture to become fine or soft?			192
A change in hair texture to become coarse or stiff?			193
Unusually dry skin?	2		194
Unusually oily skin?			195
Trouble with hemorrhages in your skin?			196
Tendency to bruise easily?			197
Any skin rashes?			198
Any discoloration of your skin?	7		199
Any moles removed?	2		200
Frequent pimples or boils?			201
Excessive sweating?			202
Excessive loss of hair?	1		203
Chills?			204
Periods of recurrent chills?			205
Air sickness?	5		206
Other motion sickness?	4		207
A severe electrical shock?	1		208
Carbon monoxide poisoning?			209
An abnormal amount of fat in your blood?			210
Sensitivity or allergy to any drugs?	1		211
Any severe fevers or elevated temperatures?	2		212
Intolerance to any foods (foods that disagree with you)?			213
A blood transfusion?			214
Spinal fluid drawn off or a spinal tap performed?	1		215
Spells of uncontrollable laughing?			216
A period where you were delirious?			217
Frequent financial worries?			218
A period of loss of memory? (for example, associated with an accident)?			219
Something like a dream when you thought you were awake?	1		220
Any supernatural experiences?			221
Frightening thoughts that keep coming back in your mind?			222
Frightening dreams that awakened you out of your sleep?	5		223
Difficulty keeping up with other children when you were a child?			224
Marked fluctuations in your body weight which occurs independently of intentional dieting?			225
An unusually poor appetite?			226
Pain in hands, face or feet on exposure to cold?			227
Headaches?	2		228
Pounding headaches and flushing of the face?			229
Intermittent swelling of the face for reasons other than injury or localized infection?			230

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD (Check Yes or No)	1 YES	2 NO	
Pain in any region of the face?			231
Iritis?			232
A lump in the eye lid?			233
Double vision?			234
Objects appear double to you even when one eye is shut?			235
Spots before you eyes or in your field of vision?	1		236
Absence of one-half of your field of vision in one or both eyes?			237
Color blindness?			238
Less tolerance to bright sunlight than other people?			239
Burning or itching of the eyes?			240
Continual blinking or watering of your eyes?			241
Pain in the eye?	1		242
Swelling of the eyelids in the morning?			243
Swelling of the eyelids at any other time for reasons other than injury?			244
An operation on the eye?			245
An injury to the eyeball?	2		246
Hemorrhages or bleeding into the eyes?			247
A colored halo around lights at night?			248
A pulling sensation of the eyes?			249
A sensation frequently of a full or pressure feeling in the eye?			250
Any greater than average difficulty seeing at night?			251
That your eyes were yellow in color, or showed yellow jaundice?			252
Dental surgery?	13		253
Partial or complete dental plates?	3		254
A removable bridge?	3		255
A fixed bridge?	1		256
Pyorrhea (peridontal infection)?			257
Bleeding or tender gums?	2		258
Trouble with foul breath or halitosis?			259
An unusual amount of bleeding following dental extraction?			260
Excessive dryness of the mouth?			261
A problem with stuttering?			262
Slurred speech or other difficulty in speaking clearly?			263
Difficulty pronouncing words clearly?			264
Difficulty chewing your food?			265
Any abnormality in your sense of taste?			266
Any sores inside the mouth?	2		267
Pain in your teeth?			268
Pain when you forcefully bite together?			269
Any teeth that are unusually sensitive to cold?			270
Any teeth that are unusually sensitive to heat?			271
Dental pain at high altitude?			272

SAM HQ FORM FEB 63 0–18f

PAGE 3 OF 7 PAGES

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Frequent head colds?			273
An injury to the ear?	2		274
Surgery of the ear?	1		275
A ruptured ear drum?	1		276
Bleeding from the ear, other than due to a local scratch?			277
A draining ear?	1		278
An ear infection?	5		279
Tenderness and swelling of the ear?	2		280
Fungus of the ears?	5		281
Trouble with your ears after swimming?	1		282
A plugged up ear not associated with flying?	4		283
Aerotitis *(Pain in the ear associated with flight)?*			284
A severe ear ache?	8		285
A sense of fullness in the ear?	2		286
A temporary or permanent hearing loss?	2		287
Increased hearing acuity until normal sounds are uncomfortable or disturbing?			288
Vertigo *(dizziness or sensation of spinning)?*	16		289
Tinnitus *(ringing or buzzing in the ear)?*	1		290
Nasal treatment of any type?	1		291
Nasal surgery?	2		292
Difficulty in smelling various odors?			293
Nose bleeds other than from injury?	1		294
Nasal obstructions?	2		295
Trouble breathing through the nose?			296
Nasal polyps?			297
A fractured nose?	4		298
Frequent pain around the nose or base of the nose?			299
Excessive nasal discharge other than with a head cold?	1		300
Frequent secretions in the back of the mouth *(post-nasal drip)?*			301
Frequently stuffed up nose?			302
Frequent itching of the nose?			303
Excessive sneezing?			304
Allergy of any type resulting in nasal discharge?			305
Tonsils and adenoids out?	27		306
Any other surgery on the throat?	1		307
Severe sore throat?	5		308
Hoarseness except with a cold?			309
Any change in your voice in the past year?			310
Pain when talking?			311
Loss of your voice?			312
A sense of fullness, lump or swelling in the throat?			313
Do you clear your throat frequently?			314
Difficulty swallowing?			315
Neck operation?			316
Cyst of the neck?			317
Any neck deformity?			318
Throbbing of neck vessels?			319
Pain in the neck?			320
Stiff or painful neck?			321

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Limitation of motion of your neck?	1		322
Any enlargement of neck glands?	4		323
Bad chest colds?			324
Difficulty with breathing?			325
Shortness of breath while lying down?			326
Shortness of breath that awakens you from sleep?			327
Shortness of breath while sitting up?			328
Shortness of breath after eating?			329
Any difficulty keeping up with others because of shortness of breath?			330
Wheezing of the lungs?			331
A recurrent cough?	1		332
Frequent coughing spells?			333
Coughed up blood?			334
Coughed up pus?			335
Coughed up foamy material in large amounts?			336
Frequent hiccups?			337
Fluid on the lungs or in the chest?			338
Fluid drawn off your chest cavity?			339
Any surgery on your chest or lungs?	1		340
Air sacs or cysts of the lungs?			341
A spot on the lungs?	1		342
A collapsed lung?			343
Received x-ray treatment of the chest?	2		344
Contact with anyone having tuberculosis?	2		345
Any chest injuries?	1		346
Any injury to any large blood vessels?			347
Trouble with your circulation?			348
Taken medicine for your heart?			349
Any operations on your heart?			350
Any operations on a large blood vessel?			351
High blood pressure?			352
Coronary heart disease?			353
Hardening of the arteries?			354
A heart murmur?			355
Heart damage from an infection or other illness?			356
An abnormal electrocardiogram?	1		357
Enlargement of the heart?			358
Any other heart trouble?	1		359
Varicose veins?			360
Thrombophlebitis?			361
Difficulty sleeping on your left side because of chest discomfort?			362
Sensations of pressure or fullness in your chest?			363
Pain along the breast bone or sternum?			364
Pain in the left side of the chest?			365
Pain in the right side of the chest?			366
Chest pain associated with pain in the left arm?			367
Chest pain associated with pain in the right arm?	1		368
Chest pain associated with pain in the jaw or teeth?			369
Chest pain while doing physical exertion or following physical exertion?			370

SAM HQ FORM FEB 63 O-18f

07 AEROMEDICAL SURVEY – SYSTEM REVIEW (Continued)

SOCIAL SECURITY NUMBER	NAME *(Last, First, MI)*	DATE OF QUESTIONNAIRE MONTH	DAY	YEAR

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Chest pain while walking against a cold wind?			371
Chest pain during or as a result of anger?			372
Chest pain during intercourse?			373
Any chest pain that awakened you from sleep?			374
Pain in the chest on deep breathing or motion?	2		375
Pain in the chest which bothers you at night that is relieved by sitting upright?			376
Any other forms of chest pain?	1		377
Sensations of your heart skipping a beat or flopping over?			378
Thumping of your heart while resting or sitting?			379
Marked racing of your heart while sitting or resting?			380
Any irregularity of your heart?			381
Trouble with a fast pulse?			382
Trouble with extremely slow pulse?			383
Any swelling of the abdomen?			384
Any masses or tumors in your abdomen?			385
A hernia?	1		386
Removal of fluid from your abdomen?	2		387
Air or other injections into the abdomen?			388
An appendectomy?	3		389
Any other surgery of the abdomen?	1		390
An x–ray of the stomach or intestines?	11		391
Disease of the pancreas?			392
Any difficulty of the esophagus?			393
Any sensation of your food sticking in the middle of your chest after swallowing?			394
Any pain on swallowing either food or water?			395
A hernia through the diaphragm?			396
A hiatal hernia or hernia of the stomach through the diaphragm?			397
Any constant stomach difficulty?			398
Frequent indigestion?			399
An abnormal amount of acid in your stomach?			400
Recurrent or intermittent pain anywhere in your abdomen?			401
Severe stomach pain?			402
Discomfort in the stomach at night that awakened you?			403
Pain in the upper part of your abdomen?			404
Discomfort in the upper portion of your abdomen after eating or after exercise?			405
Any pain in your abdomen that is increased by eating food?			406
Any stomach aches or discomforts or burning which is relieved by food?			407
Any stomach discomfort which is relieved by milk or baking soda?			408
Sensations of pressure of gaseous distension in the upper part of your abdomen?			409

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Frequent belching after eating?			410
Belching up of a sour taste into the back of your mouth?	1		411
Frequent distention of your abdomen, stomach or bowels with gas?			412
Nausea or upset stomach?			413
Any episodes of vomiting of any type that did not appear to be associated with food poisoning?	3		414
Vomiting of bloody material?			415
Vomiting of coffee grounds-like material?			416
Pain during your bowel movements?			417
Excessive straining at the stool in order to move your bowels?			418
Pain in the rectum?			419
Rectal polyps?			420
Hemorrhoids or piles?			421
Any bleeding from piles?			422
A hemorrhoidectomy?			423
A pilonidal cyst?			424
A rectal fistula or abscess?	1		425
Itching about the rectum?	1		426
Any bright red blood on the toilet tissue after a bowel movement?			427
Any light chalky or clay colored stools?	3		428
Thin and pencil shaped stools?	3		429
Much mucus in your stools?			430
Any pus in your stools?			431
Any bright red blood mixed in the stool with the bowel movement?	2		432
Any dark bloody material mixed in the stool of a bowel movement?	2		433
Any black or tarry bowel movements?	2		434
Large, bulky, foul-smelling stools?	1		435
Any other parasites, bacteria or form of infection of the bowels?	1		436
Irregular bowels?	5		437
Constant, intermittent or recurrent loose bowel movements or diarrhea?	1		438
Constant, recurrent or frequent constipation?			439
Any recent change in the number of times you move your bowels a day or type of bowel movement *(liquid or solid)*?			440
Excessive passing of gas?			441
Pain in the groin or in the back?			442
An operation on the kidney?			443
A kidney stone?			444
Pyelitis or infection of the kidney?	1		445
Dropped kidney?			446
Bright's disease?			447
An infection of the kidney?			448
X-rays of your kidneys or bladder?	6		449
Instrument examination of the bladder?	2		450

PAGE 5 OF 7 PAGES

SAM HQ FORM FEB 63 O–18f

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Cystitis or an infection of the bladder?	1		451
Catheterization in order to pass your urine or for any other reason?			452
Blood in your urine or passed blood while urinating?	1		453
Pus in the urine?	1		454
Sugar in your urine?	1		455
Albumin or protein in the urine?	2		456
Red urine?			457
Dark or black urine?			458
More frequent urination during the day than you think is common?			459
Inability to control your bladder or urination?			460
Difficulty in passing your urine?			461
Trouble starting or stopping your stream when you urinate?			462
Burning pain when you urinate?	2		463
To get up at night to pass water?	1		464
Any recent change in your sexual activity or interests?			465
Any sterility problem *(inability of your wife to become pregnant)*?			466
Any worries about your sexual adjustment?			467
Any sexual difficulties?			468
Fungus, or "jock itch" around the privates?	2		469
Pain in your penis?	2		470
An injury to the penis?			471
Trouble obtaining an erection?			472
A discharge from your genitals *(privates)*?	2		473
Urethritis?	2		474
Prostatitis or infection of your prostate gland?	2		475
Enlargement of your prostate gland?			476
An injury to your testicles?			477
Decreased size of one or both of your testicles after a known injury or known illness?	1		478
Swelling or enlargement of either testicle?	1		479
Unusual tenderness or pain in either testicle?			480
Fluid withdrawn from your scrotum?	1		481
Surgery on either testicle or any part of your privates other than circumcision?	2		482
Does arising from a seated position seem to require more physical effort than it should?			483
Any difficulty or clumsiness on walking or climbing stairs?			484
Stiffness of the joints and muscles on arising in the morning?	2		485
Difficulty maintaining your balance?			486
Difficulty walking in the dark?			487
Frequent or severe burning sensation in the fingers, toes or feet?			488
Pronounced changes in color of the fingers or toes?			489
Pain or extreme paleness of your fingers or toes?			490
Excessive sweating of hands or feet?	1		491
Any trouble with your hands or feet in cold weather?			492

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Frost bite of feet, hands, fingers or toes?			493
Dislocation or injury to any joint?	7		494
Stiff or painful joints?	3		495
Limitation of motion of any of your joints?			496
Swelling of the joints?	1		497
Any change in the shape or surface of your finger nails or toe nails?			498
Frequent muscle cramps?			499
Any muscle that feel painful when massaged or touched?			500
Any muscles that have developed unexplained weakness?			501
Unusual weakness of any muscles after minimal use?			502
Frequent muscle twitching?			503
Any change in the size of any of your muscles *(smaller or larger)*?	1		504
Twitching of your arms or legs when you were a child?			505
Pain in the shoulder?	1		506
Pain in your left arm?			507
Pain in your right arm?			508
Frequent pain in your hand or wrist?			509
Pain in the hands or fingers?			510
Pains in the tip of one or more fingers?			511
Swelling of either shoulder?	1		512
Swelling in your arm pits?			513
Swelling of either arm?			514
Swelling of the elbow?			515
Swelling of either hand?			516
Swelling of your fingers?	1		517
Operations on either shoulder, arm or hand?			518
Broken bones in either shoulder arm or hand?	14		519
Injuries to either shoulder?	2		520
Injuries to either elbow?	1		521
Injuries to either hand?	4		522
Any increase in the size of your hand since age 25?			523
Any change in ring size?			524
Deformities of either arm or hand?			525
Paralysis of either arm or hand?			526
Lumps or nodules on elbows or arms?			527
Discoloration of palms?			528
A numbness or tingling in either arm or hand?	1		529
Do your hands feel cold?			530
A tremor or shaking of your hands?	1		531
Difficulty releasing your grip after you grasp an object in your hand?			532
Loss of muscle strength in either arm?			533
A tendency to be clumsy when using your hands and arms?			534
Stiffness of the back on arising in the morning?	1		535
Frequent low back pain?			536
Severe episodes of back pain?			537
Back pain requiring you to stop work for a day or more?			538

SAM HQ FORM FEB 63 O-18f

07 AEROMEDICAL SURVEY – SYSTEM REVIEW (Continued)

SOCIAL SECURITY NUMBER	NAME *(Last, First, MI)*	DATE OF QUESTIONNAIRE: MONTH	DAY	YEAR

VI. (Cont'd) DO YOU HAVE, HAVE YOU EVER HAD, OR HAVE YOU EVER BEEN TOLD THAT YOU HAD *(Check Yes or No)*	1 YES	2 NO	
Any deformity of back or spine?			539
Any severe back injury?	1		540
A slipped disc?			541
Spine operations?			542
Deformity of your hips, legs or feet?			543
A rash on the thigh or leg?	1		544
Unusual swelling or enlargement of the veins in your legs?			545
Swelling of the inner aspect of the thigh?			546
Any unusual swelling at the back of the knee joint?			547
Swelling of the knees?	2		548
Swelling of your ankles?	2		549
Swelling of your toes or feet?			550
Sharp flash-like pains going down your legs?			551
Aching or pain in the buttocks while walking?			552
Severe or recurrent pain in the hip or thigh?			553
Pain in the calf of your leg while walking?			554
Loss of hair over the tops of your toes or feet?			555
Tired sensations in the leg or thigh muscles during ordinary walking?			556
Trouble with the skin of your feet?	1		557
Severe or frequent numbness and tingling in the feet?			558
Sores or ulcers on your feet or legs?	1		559
Burning sensations in the feet during or after exercise?			560
Marked redness of toes or feet?			561
Unusual tendency for your toes or feet to become red or swollen after exposure to heat or cold?			562
Frequent leg cramps?			563
Leg cramps that wake you up at night?	5		564
Paralysis of any muscles in either hip, leg or foot?			565
A trick or locking knee?	2		566
Injury or fracture to either hip, leg or foot?	5		567

VII. DURING THE PAST 3 YEARS HAS YOUR JOB CAUSED YOU TO WORK CLOSELY WITH *(Check Yes or No)*	1 YES	2 NO	
Chemical processes?			568
Petroleum products?	3		569
Welding operations?	3		570
Solvents *(including aircraft engine cleaners)*?	2		571
Teletype machines?			572
Missile propellants?	1		573
Radar or microwave devices?	10		574

VIII. ANSWER THE FOLLOWING QUESTIONS *(Check Yes or No)*	1 YES	2 NO	
Have you traveled outside the United States during the past six months?	10		575
If so, did you experience any illnesses or develop any symptoms during or shortly after the trip?	1		576
Do you ever fall asleep for short periods of time even though you have had adequate sleep the night before?	2		577
Do you ever seem to confuse your thoughts with someone else's thoughts, as if someone might be putting things into your mind or even saying things to you?			578
Have you seen your dentist within the last year?	30		579
Do you use glasses for any reason?	2		580
Has it been more than a year since you last had your eyes checked?			581
Do your eyes ever feel as if they were crossed?			582
Have you ever been told you should not participate in school athletic programs?	1		583
Do you get up at night to eat or get a glass of milk?			584
Have you knowingly been exposed to any source of radioactivity or x-radiation at any time in your life?	4		585
If so, was this followed by a period of nausea, vomiting, diarrhea, fever, unexplained bruise marks or sudden loss of hair			586
Has any of your work or hobbies required you to be exposed to carbon tetrachloride *(carbon tetrachloride is contained in many solvents, cleaning materials and fire extinguishers; it is frequdntly used in dry cleaning and degreasing agents. Some of the commercial products which contain this include Asordin, Chlorasol, Carbona, Phoenipine, Katarine, Pyrene, Spectral, Tetra, Tetracol, tetraloam)*?			587

SAM HQ FORM FEB 63 O-18f

PAGE 7 OF 7 PAGES

PHYSICAL EXAMINATION

Prior to the individual's reporting to the USAF School of Aerospace Medicine for evaluation each man had had a recent physical examination. In the case of military officers these are usually relatively comprehensive; whereas, in the case of civilian candidates the opportunity to obtain an equally comprehensive examination is not always available.

At the time of the aeromedical evaluation a physical examination is accomplished by a group of specialists each highly trained in his own individual specialty area. The majority of the significant findings noted upon such a comprehensive examination are included within the detailed reports from the various specialty areas.

In 13 individuals there were no significant positive physical findings (other than enucleation of tonsils).

Nasal septal deflection without obstruction to the airway was noted in three individuals and an exostosis of the external auditory canal in one person.

Functional cardiac murmurs were noted in four individuals. Minor scars and one minimal keloid scar were noted. Mild hemorrhoids were reported in one subject and a mildly large prostate in another. One individual had a varicocele, another an atrophic testis and still another an absent testis replaced by a prosthesis. Two individuals were reported to have bilaterally relaxed inguinal rings with no evidence of hernia. One individual had a small hernia which is discussed in the surgical section. Asymptomatic Pes Cavus was noted in one individual. Of the 32 candidates evaluated successively in this position of the analysis a height restriction of 72 inches had been imposed. One individual exceeded this height but, nevertheless, was selected to participate in a space program without this limitation on physical height.

The form used for physical evaluation is the Standard Form 88 customarily used by the Armed Forces. More detailed reports and procedures are contained within the report from the individual specialty areas.

DENTAL EVALUATION

Robert A. Brolling, Capt., USAF, DC

A clinical examination of all oral structures, supplemented by a complete series of dental radiographs, was accomplished on each individual in this group. All existing restorations and fixed and removable partial dentures were evaluated.

Emphasis was directed to those disease processes which can elicit painful manifestations thereby creating an immediate requirement for treatment.

The results compiled at the termination of the period during which 32 subjects were examined are listed in Table I.

Table I

Dental findings

Significant findings	Number of individuals
Missing tooth, n.e.c. (third molar teeth included)	24
Impaction, tooth	6
Nonfunctional tooth (third molar tooth included)	4
Unerupted tooth (not impacted)	1
Caries, dental	8
Replacement, dental operative restoration	5
Calculus, dental	23
Gingivitis, n.e.c.	14
Periodontitis	5
Erosion, tooth	8
Hypersensitive dentin	6
Ulcer of mouth, traumatic	3
Abscess, periapical, chronic	1
Torus mandibularis	2
Attrition, tooth	1
Bruxism	1
Leukoplakia buccalis*	1
Desquamating epithelial tissues of the cheek mucosa resulting from cheek biting*	1
Herpes simplex	1

*Diagnosis unconfirmed

PATHOLOGY EVALUATION

LABORATORY EXAMINATION

James R. Clay, Major, USAF, MC

As a routine practice all individuals reporting for aeromedical evaluation to the USAF School of Aerospace Medicine are given preliminary instructions; these include diet and fasting instructions. Each individual's first stop at the beginning of his examination is to the clinical laboratory where all biological specimens are obtained. The examination is designed to minimize the number of venipunctures. Thus a blood sample is drawn of sufficient quantity to permit examination of all the various procedures which will be carried out. This is immediately followed with the two-hour glucose tolerance test described below.

It has been found that when a number of different specialists are simultaneously examining the same subject that much time can be saved and confusion avoided if the entire battery of examinations is ordered initially. This prevents multiple venipunctures and provides for an organized approach to the laboratory evaluations. The team carrying out the laboratory determinations is accustomed to doing this extensive procedure daily on individuals referred from the flying population. As a result, no test is modified or added specifically for a crash program. This tends to maintain quality and uniformity of results. Occasionally, pre-planned laboratory studies of this nature need to be modified when a test subject has had some minor illness, such as unexpected gastroenteritis, which could significantly influence the test results. Additional studies are then repeated on an individual basis, because of abnormal laboratory results or clinical indication.

A series of clinical laboratory procedures is performed on each of the potential space pilots. The tests are simple; yet, their selection is designed to evaluate the major systems of the body. Tables are given which show the various laboratory measurements in 32 space pilot candidates and compare them to a control group. These procedures are done on all space pilot examinations. The control group consists of individuals between the ages of 30 and 35 who were referred to the USAF School of Aerospace Medicine because of one or more episodes of loss of consciousness. In each instance, no organic disease was found and syncope with adequate cause was the final diagnosis. Since all the tests were not done on all of these patients, the number of control subjects varies from test to test. In each instance the number of control patients is given. This group should represent the average USAF flying population as compared to the space pilot.

Certain additional tests were performed on individuals when indicated. These are mentioned later in this section.

Hematology

White blood cell counts are made on a standard blood cell counting chamber using dilute acetic acid to lyze the red cells. Table I shows that the counts of all the space pilots fell within the normal range except for one individual with a slightly low count. No particular significance was given to this since the differential count and morphology were normal. It is of interest, however, that this individual also had hemoglobin and red blood cell counts that were relatively low (14.8 Gm and 4,800,000).

Differential white cell counts are made on Wright-stained smears of fresh, non-anti-coagulated blood. One hundred white cells are counted. Four space pilots had 6 percent eosinophils on the first count. Repeat counts on subsequent days were generally lower. No parasites or other diseases were found to account for this slight elevation. Several individuals had had recent over-exposure to sunlight and this might have been a factor.

Platelets are estimated from the peripheral blood smears with calculations based on the red cell counts. The laboratory is prepared to do platelet counts by phase microscopy if any of the counts appear abnormal. Counts for all the space pilots were within normal range.

Red blood cell counts are made on the standard counting chamber using Hayem's solution as a diluent. One individual had

Table I

	WBC/cu mm		% Neutrophils		% Lymphocytes		% Eosinophils		Platelets/cu mm	
	Space pilots	Controls (50)*	Space pilots	Controls (48)	Space pilots	Controls (48)	Space pilots	Controls (48)	Space pilots	Controls (48)
Lowest value	4,000	4,650	46	44	23	15	0	0	240,000	200,000
1st quartile	5,300	6,250	52	53	33	31	1	1	250,000	250,000
Median	6,200 - 6,500	7,250 - 7,300	56	57	39	37	2	2	268,000-270,000	270,000
3d quartile	7,500	8,850	60	64	43	42	4	3	288,000	281,000
Highest value	9,950	15,000	70	80	47	49	6	9	320,000	330,000
Mean	6,250	7,630	56	58	38	39	2	2.5	271,000	266,000

*Number of control subjects

an initial count of 4,300,000 cells/cu mm with a subsequent count of 4,150,000. The hemoglobin and hematocrit were correspondingly low. No explanation can be offered for this low value. The remaining values were normal. See table II.

Hemoglobin is measured by the cyanmethemoglobin method. Two values of 13.3 Gm were found. All others were normal.

Hematocrits are determined by the micro method using capillary tubes and a high-speed centrifuge. Heparin is used as an anticoagulant. Average values are slightly higher with heparin than with some oxalates because there is less cell shrinkage with heparin. Our values are consequently a little higher than many of the values given in standard texts. The space pilot group compares well with the control group.

Erythrocyte sedimentation rates are measured with the standard Wintrobe tube and read at one hour. Corrections are made based on the hematocrit and both values are given. Table II refers to uncorrected values.

Bleeding times are determined from finger sticks. Values are generally slightly lower than published data using ear lobe sticks but compare well with the control group. No prolonged bleeding times were found. See table III.

Clotting times are measured by the capillary tube method. Here also the values are slightly lower than published data but compare well with the control group.

Prothrombin times are measured by the method of Quick using a commercial thromboplastin-calcium mixture (Simplastin, Warner-

Table II

	RBC million/cu mm		Hemoglobin Grams/100 ml		Hematocrit		Erythrocyte Sedimentation Rate	
	Space pilots	Controls (50)	Space pilots	Controls (50)	Space pilots	Controls (50)	Space pilots	Controls (48)
Lowest value	4.30	4.25	13.3	13.2	44	43	1	1
1st quartile	4.80	4.70	14.4	14.4	47	46	2	2
Median	5.00	5.00	15.0	14.8	48	48	4	3
3d quartile	5.20	5.30	15.2	15.3	50	50	6	6
Highest value	5.50	5.89	16.5	16.0	53	59	16	14
Mean value	5.13	5.03	14.8	14.7	48	48	4.6	4.8

Table III

	Bleeding Time		Clotting Time		Prothrombin Time*	
	Space pilots	Controls (24)	Space pilots	Controls (24)	Space pilots	Controls (24)
Lowest value	0'30"	0'30"	3'00"	2'00"	0.0	0.0
1st quartile	1'00"	1'00"	3'45"	3'30"	0.5	0.5
Median	1'15" - 1'30"	1'30"	4'30"	4'00"	1.0	0.5 - 1.0
3d quartile	1'30"	2'10"	5'00"	4'30"	1.5	1.5
Highest value	2'30"	3'15"	6'00"	5'30"	2.5	3.0
Mean	1'20"	1'15"	4'30"	4'00"	1.0	1.0

*Deviations in seconds from control plasma.

BLOOD GROUPS

Group	Nr of space pilots
A	11
O	15
B	3
AB	3

BLOOD TYPES

Type	Nr of space pilots
D +	26
D -	6

Chilcott Laboratories). Prothrombin times are compared to those obtained with commercial control plasma and both values are reported. Table III shows the deviations in seconds from the control plasma.

Blood groups are determined by standard commercial typing sera, using the slide technic.

Rh typing is limited to determination of D(Rh_o) using commercial anti-D sera and the slide technic.

Hemoglobin electrophoresis is done on all subjects. All individuals demonstrated the pattern for hemoglobin A.

Reticulocyte counts were done on two space pilot candidates using New Methylene Blue stain. Values of 1.5 percent and 0.5 percent were obtained.

Direct Coombs test was done on one individual with a hemoglobin Of 14.4 Gm. This was negative.

Red blood cell fragility to hypotonic saline was done on one subject. Lysis began at 0.44 percent and was complete at 0.28 percent saline. This was considered normal.

Blood Chemistry

Glucose tolerance tests are done on all space pilot examinations. All subjects are prepared by ingesting a high carbohydrate diet for three days prior to the test, then fasting for 12 hours immediately before the test. One hundred grams of glucose is given by mouth. Blood glucose levels are determined during fasting and after glucose ingestion at 1/2 hour intervals for 2 hours. The Somogyi-Nelson technic is used. One candidate had a diabetic curve on initial examination. A repeat examination several days later produced a normal curve. All other individuals had normal curves. See table IV.

Acid and alkaline phosphatases are determined by the Shinowara, Jones, Reinhart method. All tests are done before rectal or prostatic examination. See table V.

Blood urea nitrogen determinations are made using diacetyl monoxime as described by Ormsby. Both the space pilot group and control group contained a few individuals with more than 20 mgm/100 ml. When these determinations were repeated several days later, the values were all in the normal range. Dehydration and diet are likely factors in producing the high values.

Serum sodium is measured on a standard flame photometer (Coleman). See table VI.

Serum potassium measurements are made by flame photometry (Coleman).

CO_2 combining power is measured by the manometric method of Van Slyke and reported as bicarbonate.

Serum chlorides are determined by the Schales and Schales method as modified by Caraway and Fanger.

Serum calcium is measured by flame photometry (Coleman). All values for the space pilot group were in the normal range

Table IV

Glucose Tolerance Tests mgm/100 ml

	Fasting		1/2 hour		1 hour		1-1/2 hour		2 hour	
	Space pilots	Controls (51)	Space pilots	Controls (36)	Space pilots	Controls (36)	Space pilots	Controls (36)	Space pilots	Controls (36)
Lowest value	74	66	116	63	67	70	66	59	58	60
1st quartile	86	82	126	114	97	102	80	79	82	68
Median	91 - 92	86	140 - 141	130 - 132	128 - 129	120 - 123	91	92 - 93	89 - 91	90
3d quartile	94	94	160	154	144	142	106	120	106	102
Highest value	104	114	234	198	216	213	192	163	142	134
Mean	90	87	146	136	126	125	95	98	92	87

Table V

	Serum Acid Phosphatase SJR units		Serum Alkaline Phosphatase SJR units		Blood Urea Nitrogen mgm/100 ml	
	Space pilots	Controls (25)	Space pilots	Controls (25)	Space pilots	Controls (39)
Lowest value	0.0	0.0	1.1	1.4	10	9
1st quartile	0.0	0.0	1.8	1.8	13	13
Median	0.0	0.4	2.3	3.2	16	16
3d quartile	0.3	0.6	2.5	3.8	18	20
Highest value	0.7	1.8	6.1	7.2	22	27
Mean	0.16	0.4	2.4	3.0	16	17

except for one determination of 8.8 mgm/100 ml. All other tests were normal on this individual. Generally the calcium level was lower in the space pilot group than in the control group. See table VII.

Serum inorganic phosphorus is measured by the method of Fiske and SubbaRow. Both the control group and the space pilot group showed a wider spread of values than would be anticipated. There was generally good correlation between the groups.

Uric acid is measured by the Brown modification of the Folin method. All results were in the normal range.

Serum bilirubin is determined by Ducci and Watson's modification of the Malloy-Evelyn technic. Three individuals had total bilirubin values higher than 1 mgm/100 ml. One subject had total values of 1.4, 1.25, and 1.95 mgm with indirect values of 1.05, 0.88, and 1.45 mgm. His hemoglobin was 14.4 Gm; Coombs test, negative; osmotic red cell fragility, normal; reticulocyte count, 0.5 percent; urine urobilinogen, a trace at dilution of 1:10, and negative at dilution 1:20; urine bile, negative; bromsulfalein excretion test, 2 percent of the dye remaining after 45 minutes. There was no history of hemolytic disorders, liver disease, unusual exposure to toxic agents, or jaundice. This was considered to be congenital idiopathic hyperbilirubinemia. The other two subjects with elevated values of 1.25 and 1.15 mgm/100 ml had similar negative histories and essentially normal laboratory

Table VI

	Serum Sodium mEq/L		Serum Potassium mEq/L		CO_2 Combining Power mEq/L		Serum Chloride mEq/L	
	Space pilots	Controls (25)	Space pilots	Controls (25)	Space pilots	Controls (25)	Space pilots	Controls (25)
Lowest value	136	138	3.9	3.7	22	25	94	97
1st quartile	139	140	4.2	4.2	27	27	100	100
Median	140	142	4.4	4.5	29	28	103	102
3d quartile	141	142	4.6	4.9	30	28	105	104
Highest value	145	144	5.1	5.3	33	30	107	109
Mean	140	141	4.4	4.5	29	28	102	102

Table VII

	Serum Calcium mgm/100 ml		Serum Phosphorus mgm/100 ml		Serum Uric Acid mgm/100 ml	
	Space pilots	Controls (26)	Space pilots	Controls (25)	Space pilots	Controls (24)
Lowest value	8.8	9.0	2.3	2.3	3.5	2.7
1st quartile	9.2	9.6	2.7	2.8	4.6	4.1
Median	9.6	9.8	3.4	3.5	5.0	4.4 - 4.5
3d quartile	9.8	10.2	4.1	3.9	5.4	5.2
Highest value	10.0	10.6	4.9	4.7	6.0	6.7
Mean	9.5	9.9	3.5	3.4	4.9	4.6

data. None of the control group had elevated values. See Table VIII.

Thymol turbidity is determined by a modified Maclagen technic with a reagent pH of 7.55. Measurements are made photometrically and reported as Maclagen units. All values were within normal limits.

Cephalin-cholesterol flocculation test is done according to Hanger's method using commercial cephalin-cholesterol antigen.

Serum transaminases are measured using a commercial kit (Dade). A few slight elevations were found but, in view of the histories, they were not considered significant.

Total serum proteins are measured by the biuret method. All values were normal. Fractionation of serum proteins is done by paper electrophoresis (Spinco) with analysis by the Analytrol. No abnormal globulins were found and the results were all considered normal. See tables IX and X.

Protein-bound iodine is measured by a wet ash technic by the 6570th Epidemiological Laboratory, Lackland AFB. See table XI.

Creatinine is measured by the standard Jaffe reaction using picric acid as described by Benedict. The range of values in the control group was much wider than that of the space pilot group. All of the latter were normal.

Total serum lipids are estimated by the phenol turbidity method of Kunkel. This method has been satisfactory when lipids

Table VIII

	Total Serum Bilirubin mgm/100 ml		Direct Serum Bilirubin mgm/100 ml		Indirect Serum Bilirubin mgm/100 ml		Thymol Turbidity units		SGOT units		SGPT units	
	Space pilots	Controls (25)	Space pilots	Controls (25)	Space pilots	Controls (25)	Space pilots	Controls (24)	Space pilots	Controls (24)	Space pilots	Controls (24)
Lowest value	0.3	0.25	0.15	0.20	0.1	0.00	0.50	0.30	0	5	6	6
1st quartile	0.4	0.50	0.20	0.25	0.2	0.25	0.75	0.75	22	22	15	15
Median	0.5 - 0.6	0.50	0.25	0.25	0.3	0.25	1.00	1.00	33	27	22	22
3d quartile	0.7	0.70	0.30	0.25	0.4	0.40	1.25	2.00	38	38	25	29
Highest value	1.95	1.00	0.50	0.35	1.0	0.75	2.30	3.00	50	50	29	37
Mean	0.6	0.60	0.26	0.26	0.3	0.30	0.98	0.96	30	28	21	23

Cephalin Flocculation

	24 hr		48 hr	
Degrees of Flocculation	Space pilots	Controls (21)	Space pilots	Controls (21)
Negative	14*	3	6	1
+	17	18	7	6
++	1	0	19	14

*Refers to number of subjects.

Table IX

	Total Serum Proteins Grams/100 ml		Serum Albumin Grams/100 ml		Total Serum Globulin Grams/100 ml	
	Space pilots	Controls (28)	Space pilots	Controls (25)	Space pilots	Controls (27)
Lowest value	6.3	6.0	4.4	3.7	1.4	1.6
1st quartile	6.5	6.8	4.7	4.4	1.6	2.0
Median	6.9	7.0	5.1	4.6	1.9	2.2
3d quartile	7.3	7.6	5.3	5.3	2.1	2.6
Highest value	7.9	8.4	5.7	6.1	2.7	3.7
Mean	7.0	7.2	5.1	4.9	1.9	2.3

Table X

	$Alpha_1$ Globulins Grams/100 ml		$Alpha_2$ Globulins Grams/100 ml		Beta Globulins Grams/100 ml		Gamma Globulins Grams/100 ml	
	Space pilots	Controls (23)	Space pilots	Controls (23)	Space pilots	Controls (23)	Space pilots	Controls (23)
Lowest value	0.12	0.15	0.30	0.25	0.40	0.46	0.39	0.44
1st quartile	0.17	0.22	0.36	0.36	0.48	0.52	0.60	0.69
Median	0.19	0.26	0.40 0.41	0.46	0.53	0.62	0.75 - 0.76	0.78
3d quartile	0.21	0.29	0.46	0.51	0.60	0.74	0.91	0.96
Highest value	0.27	0.35	0.69	0.74	0.85	1.33	1.08	1.15
Mean	0.20	0.25	0.42	0.44	0.55	0.67	0.75	0.82

Table XI

	Protein-Bound Iodine micrograms/100 ml		Serum Creatinine mgm/100 ml	
	Space pilots	Controls (24)	Space pilots	Controls (25)
Lowest value	3.5	2.5	0.62	0.67
1st quartile	4.3	4.2	1.27	0.90
Median	4.7	4.9 - 5.0	1.34	1.10
3d quartile	5.8	5.5	1.41	1.51
Highest value	6.5	13.4	1.66	1.80
Mean	4.9	5.3	1.34	1.20

are in normal range but unreliable when the lipids are elevated. When the results are high or questionable, gravimetric measurement is made. All the space pilot candidates had normal values except one who had 818 mgm/100 ml total lipids, 254 mgm/100 ml triglycerides, 250 mgm/100 ml total cholesterol, and 326 mgm/100 ml phospholipids. See table XII.

Serum cholesterol is measured by a modified Zak technic. This was described by Robinson et al., U. S. Armed Forces Medical Journal, Vol 9, No. 2, 1958. In this technic the Zak procedure is used except that acetic anhydride and sulfuric acid are used to develop color instead of ferric chloride and sulfuric acid. This has been a satisfactory technic in this laboratory. Values from the space pilot group were significantly lower than those of the control group. All of the space pilot group had normal values, whereas several controls had values above 300 mgm/100 ml.

Phospholipids are measured from an ether-alcohol extract using sulfuric acid digestion and hydrogen peroxide to free the phosphate. Phosphorus is measured and phospholipids estimated by using a factor of 25.

Serum triglycerides are separated from serum by silicic acid chromatography. Color is developed according to Van Handel and Zilversmit and measured spectrophotometrically. Tripalmitin is used as a standard, and results are reported as tripalmitin. All values were well within normal limits. One subject was

Table XII

	Total Serum Lipids mgm/100 ml		Serum Cholesterol mgm/100 ml		Serum Phospholipids mgm/100 ml		Serum Triglycerides mgm/100 ml	
	Space pilots	Controls ( )	Space pilots	Controls (54)	Space pilots	Controls (44)	Space pilots	Controls (13)
Lowest value	450	X	134	139	175	150	52	50
1st quartile	540	X	173	190	216	223	76	68
Median	579	X	191 - 195	220	241 - 255	250	89 - 90	100
3d quartile	654	X	215	248	276	280	118	136
Highest value	818	X	250	319	326	340	254	211
Mean	591	X	196	223	248	252	102	111

significantly higher than the rest of the space pilot group with 254 mgm/100 ml. It will be of special interest to follow this individual from a cardiovascular standpoint. Other than this exception, there was good correlation between the space pilot candidates and control groups.

Two subjects had bromsulphalein excretion tests. Both were normal.

Urinalyses

Routine urinalyses are done on all subjects using an early morning specimen following 12 hours of fasting. All subjects had acid urine. Specific gravities are shown in table XIII. All were examined for protein, sugar, acetone, blood, and bile and found to be negative. Urinary sediment was examined microscopically. The number of white blood cells are shown in table XIII. Three of the subjects had one or more casts in the sediment. Two had hyaline casts and one had occasional granular casts.

Qualitative urine cultures are done on clean, mid-stream samples of urine. The urine is diluted 1:1000 and plated on nutrient agar for colony counting. One individual had a colony count of over 100,000/ml. This was identified as E. coli. Urinalysis otherwise was normal on this individual. It is possible that this represented a contaminant. The remaining counts were less than 50,000/ml.

Table XIII

	Urine Specific Gravity		Urine Sediment WBC/HPF		Quantitative Urine Culture	
	Space pilots	Controls (48)	Space pilots	Controls ( )	Space pilots	Controls (6)
Lowest value	1.014	1.012	0 - 1	X	0	1,000
1st quartile	1.024	1.017	0 - 1	X	0	
Median	1.028	1.022 1.023	0 - 2	X	2,000	2,000 - 5,000
3d quartile	1.030	1.027	2 - 4	X	7,000	
Highest value	1.036	1.036	6 - 8	X	over 100,000	17,000
Mean	1.027	1.022	X	X	7,500	5,000

Urine Sediment

Nr of subjects	Casts
29	0
1	1 (hyaline)
1	Occasional (granular)
1	Occasional (hyaline)

In addition, two space pilot candidates had phenolsulfonphthalein excretion tests. One had a total two hour excretion of 63 percent. This individual also had occasional red blood cells in the urinary sediment and 20 - 35 white cells per high power field. On subsequent examinations the urine became normal except for the casts, which remained. PSP excretion on the second subject was normal.

Other

VDRL tests for syphilis are done on all candidates. All tests were negative in the space pilot and control groups.

Acknowledgment

The laboratory determinations were made by Mr. Oscar O. Clayton and Miss Dorothy F. Wease, and their respective staffs, all of the Pathology Department. Their contributions are greatly appreciated.

RADIOLOGY EVALUATION

Charles L. Randolph, Jr., Major, USAF, MC

Each potential space pilot receives a comprehensive diagnostic radiological examination. The scope of the examination, procedures used, and results in 65 successive candidates are as follows:

1. SKULL - Examination consists of a lateral, posterior-anterior, occipital and base views. To supplement these views in the evaluation of the paranasal sinuses an upright view is obtained in the Waters' projection.

The skulls and nasal accessory sinuses were found to be normal in 50 of the 65 men. Evidence of previous mastoiditis and a limited mastoidectomy was found in one individual. Four were found to have moderate to marked thickening of the membrane lining the maxillary antra. There were ten cases showing the presence of antral cysts or polyps (Fig 1).

2. CHEST - Views of the chest are obtained in posterior-anterior and left lateral projections. The latter are slightly overpenetrated in order to facilitate evaluation of the thoracic vertebrae. Examination of the thoracic spine as a separate procedure is not carried out.

All but one of the subjects had no significant abnormality on chest x-ray. One man showed evidence of right diaphragmatic adhesions resulting from pleuritis secondary to either a subphrenic abscess or pulmonary infarct.

3. SPINE - Lateral and anterior-posterior views of the lumbosacral spine and pelvis are obtained in conjunction with the cholecystogram. These views permitted visualization of the bony structures, served as

FIGURE 1

The base of the left maxillary sinus in the Waters' projection shows a dome-shaped soft tissue density due to a polyp or cyst. This shadow did not change on examination made in the horizontal position.

gallbladder scout films, and are also used as survey (KUB) films of the urinary tracts.

Oblique views of the spine are not obtained routinely but are made only when the anterior-posterior and lateral films reveal findings indicative of the need for these additional studies.

Minimal degenerative arthritic changes involving the cervical vertebrae were present in eight cases. In three of these the disease was localized about a single interspace and with minimal to moderate encroachment into the neural foramina by arthritic spurs. A unilateral cervical rib was found, and in one case there was congenital fusion of the fourth and fifth cervical vertebrae (Fig. 2).

Localized degenerative arthritis of minimal degree was seen to involve the thoracic vertebrae in two cases. The thoracic spine in one individual showed moderate degenerative changes, probably secondary to previous vertebral epiphysitis.

Examination of the lumbosacral spine revealed two of the candidates to have spondylolisthesis, grade I, at L5, S1 (Fig. 3).

4. ABDOMEN - The survey of the abdomen was normal in all cases but one. In this case the plain films showed a small calcific density to overlie the lower pole of the left kidney. Intravenous pyelography subsequently proved this to be a renal calculus.

Because of proteinuria an intravenous pyelogram was obtained on another individual and there was found to be a right nephroptosis. The right kidney descended over a distance of 8 centimeters on assuming the erect position. There was no evidence of hydronephrosis or pyelonephritis however.

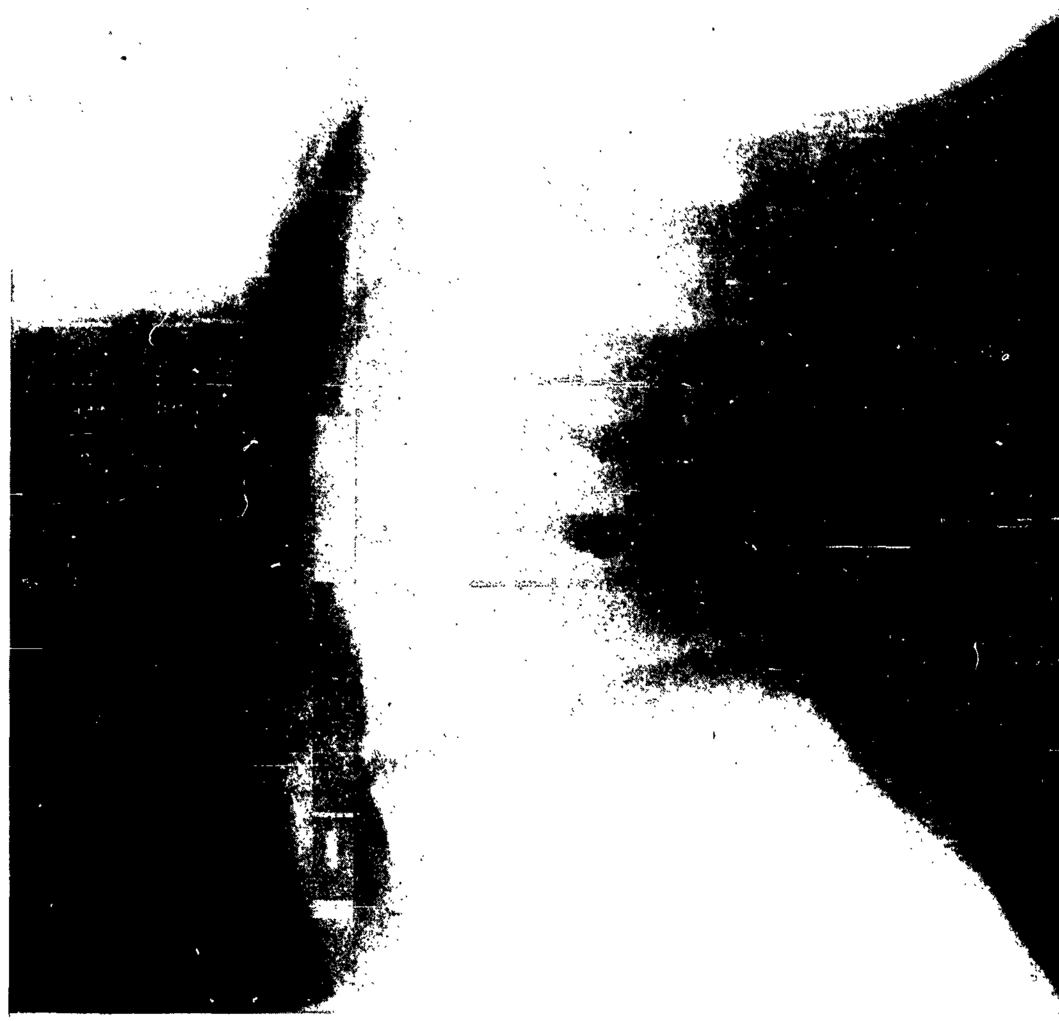


FIGURE 2

Lateral view of the cervical spine showing congenital fusion of the fifth and sixth cervical vertebrae.

FIGURE 3

Lateral view of the lumbosacral spine showing anterior displacement of the fifth lumbar vertebra with respect to the first sacral segment. Note the defect in the posterior arch of L5.

5. GALLBLADDER - Cholecystography is carried out 14 hours following the oral administration of contrast material. Localization of the gallbladder is accomplished on the lumbosacral spine views and in most cases only one additional view, either in the oblique or upright position, proves necessary for adequate visualization. The examination does not routinely include the administration of a fatty meal or other stimulus with subsequent gallbladder visualization.

No significant abnormality was found on any of the gallbladder examinations. A phrygian cap deformity was seen in two gallbladders.

6. UPPER GASTROINTESTINAL TRACT - Fluoroscopic examination of the esophagus, stomach and duodenum is carried out during the administration of a barium meal. Special attention is given to eliciting the presence of hiatus hernia or gastroesophageal reflux. At the time of fluoroscopy four spot views centered over the first part of the duodenum are obtained. Following fluoroscopy a posterior-anterior view of the abdomen and two right anterior oblique views of the stomach are made. Delayed films are omitted from these examinations.

No significant abnormalities were found on these studies. In two cases there were seen to be single,small, wide-mouthed,duodenal diverticulum.

7. COLON - Only those individuals with proctoscopic evidence of disease receive barium enema. In all of the six cases so examined there had been proctoscopic visualization of polyp(s) and accordingly, all received air contrast barium enemas, either combined with the plain barium enema, or as a separate procedure.

In none of these cases was there x-ray evidence of polyps or other abnormality.

The x-ray studies are carried out so as to yield the maximum of information while keeping radiation exposure to a minimum. Instead of examining each area or system as a separate procedure, the examinations are combined where possible so that one view can be made to serve where two or more might ordinarily be used. Specific measures to lessen or eliminate needless patient exposure are the use of fast films and intensifying screens with high kilovoltage techniques, scrupulous use of beam limiting devices, and the application of gonad shielding. The radiographic equipment is modern and is frequently calibrated and checked for radiological safety. The x-ray technicians are afforded sufficient time for their work so that few, if any, re-examinations are required because of faulty positioning or choice of exposure factors.

The fluoroscopic examinations are carried out using an image intensifier and image orthicon television system. The average factors employed are 90 kilovolts and 1 milliampere with 2 mm Al added filter. At these sittings the exposure dose at the table top is 2.4 roentgens per minute. The total fluoroscopic time for the completion of an examination rarely exceeds 3.5 minutes.

In summary, each candidate is subjected to a searching radiological examination. At the same time, radiation exposure is minimized by combining examinations wherever possible and by utilizing sound technical principles. With four exceptions the information obtained on 65 candidates was largely negative in nature in that no major abnormalities were detected. These four exceptions were two cases of lumbosacral spondylolisthesis, one case of previously unsuspected nephrolithiasis, and one case of nephroptosis.

SURGICAL EVALUATION

John M. Connolly, Major, USAF, MC

and

Lester F. Williams, Jr., Capt., USAF, MC

The surgical portion of the aeromedical evaluation of space pilot candidates consisted of the routine examination of several areas of potential disease as well as consultation regarding any surgical condition which had been or was present. The candidates were seen and examined by two General Surgeons and further consultation in the surgical sub-specialities were obtained, if needed, at the Wilford Hall USAF Hospital at Lackland Air Force Base.

All candidates were checked carefully for the presence of saphenous varicosities because of the potential hazard of significant blood pooling in the lower extremities during periods of prolonged sitting or increase in "G" forces. No candidate was noted to have significant varicose veins.

The exterior genitalia, scrotal contents, and inguinal regions were carefully examined. One candidate was noted to have a small inguinal hernia which descended one centimeter below the internal ring. The potential hazard of incarceration and strangulation of these small hernias is sufficient indication in itself for surgical correction; it is of even greater concern in the pilot population since the parachute harness crosses the inguinal hernia site and may contribute to damage to herniated bowel or omentum during the opening shock following successful deployment of the parachute. The candidate with the inguinal hernia was subjected to elective surgical repair of this hernia immediately upon returning to his home station.

One candidate had a plastic prosthesis in his scrotum which had been inserted some time previously for esthetic reasons following an operation for unilateral cryptorchism. This produced no symptoms and radiographic examination revealed it to be solid except for a few tiny air holes of such a nature that there was no possibility of significant expansion of trapped gas.

All candidates had a routine screening KUB during the course of their examination. One subject was found to have a renal calculus, and in addition, subsequent urologic evaluation revealed a mild bladder neck contracture which historically had been associated with recurrent genito-urinary tract infections in the past. It has been reported by Kohler that there is apparent increased incidence of urinary tract calculi in the flying population when compared to non-flyers of comparable age and sex. The sudden and complete incapacitation of patients with renal or ureteral colic militates against the use of individuals with genito-urinary calculi as aerospace crewmen. The potential hazards of calcium mobilization during prolonged weightlessness and the possibility of mild to severe dehydration occurring in a space mission profile when combined with even a mild degree of urinary tract obstruction and stasis poses an unacceptable risk.

Many flight surgeons have observed an apparent high incidence of anal problems, particularly hemorrhoids, in the flying population. This is usually ascribed to irregular bowel habits, dehydration, prolonged sitting on hard surface, and poor eating habits. For this reason, each candidate was subjected to digital rectal examination as well as proto-sigmoidoscopy. The patients were prepared for the examination by means of a commercially available disposable enema kit which in general provided excellent cleansing of the distal 25 centimeters of bowel. A standard examination revealed it to be solid except for a few tiny air holes of such a nature that there was no possibility of significant expansion of trapped gas.

All candidates had a routine screening KUB during the course of their examination. One subject was found to have a renal calculus, and in addition, subsequent urologic evaluation revealed a mild bladder neck contracture which historically had been associated with recurrent genito-urinary tract infections in the past. It has been reported by Kohler that there is apparent increased incidence of urinary tract calculi in the flying population when compared to non-flyers of comparable age and sex. The sudden and complete incapacitation of patients with renal or ureteral colic militates against the use of individuals with genito-urinary calculi as aerospace crewmen. The potential hazards of calcium mobilization during prolonged weightlessness and the possibility of mild to severe dehydration occurring in a space mission profile when combined with even a mild degree of urinary tract obstruction and stasis poses an unacceptable risk.

Many flight surgeons have observed an apparent high incidence of anal problems, particularly hemorrhoids, in the flying population. This is usually ascribed to irregular bowel habits, dehydration, prolonged sitting on hard surface, and poor eating habits. For this reason, each candidate was subjected to digital rectal examination as well as proto-sigmoidoscopy. The patients were prepared for the examination by means of a commercially available disposable enema kit which in general provided excellent cleansing of the distal 25 centimeters of bowel. A standard

5 centimeter anoscope and a 25 centimeter protosigmoidoscope were used for the visual examination of the lower gastrointestinal tract.

Four of the candidates were noted to have single benign adenomatous polyps confirmed by biopsy and histologic examination. One candidate was noted to have a polypoid lesion which proved to be a mucosal fold on histologic examination. Because of the discovery of these benign adenomata, an extensive review of the literature on this subject was accomplished. Information on statistically significant groups of individuals who were asymptomatic and in the age range of 30 to 40 years was not available. There were no reports of long term follow-up and ultimate course on groups with small lesions which were asymptomatic. For these reasons a definite conclusion could not be reached, but the following working concepts were formulated.

1. The overall incidence of polyps is approximately 5 - 6% (all age groups). Incidence of polyps in males under 40 (2,000 subjects) is 2.62%.

2. 86% of polyps are within the distal 25 centimeters of the colon.

3. Approximately 10 - 15% of the polyps are multiple.

4. The incidence of malignancy varies with size.

   a. Less than 0.5 centimeters - 1.5% malignancy.

   b. 0.5 - 1.0 centimeters - 3.5% malignancy.

   c. 1 - 2 centimeters - 18% malignancy.

   d. 2 - 5 centimeters - 21% malignancy.

5. Incidence of new polyps occurring subsequent to the original polyps (5 year follow-up):

a. If the original polyp was singular - 38% new polyp.

b. If the original polyp was multiple - 56% new polyp.

6. Development of subsequent carcinoma of the colon:

a. In the average population without known polyps - less than 2%.

b. In the population with known benign polyps - approximately 3%.

Based on this review of the literature, pertinent references from which are included as an attachment, the following opinions were expressed.

There is an apparent, although admittedly slight, increased probability of the ultimate development of carcinoma of the colon in an individual known to have demonstrated benign adenomata, when this individual is compared with the population without such colonic lesions; however, the incidence is slight and in a medical situation which permits frequent proper reevaluation, it is not felt that such lesions should be considered a disqualifying defect for an individual otherwise qualified for advanced training.

REFERENCES

1. Turell, R. Colonic Adenomas, Am. J. Surg., 76:783, 1948.
2. Rider, J. A., Kusner, J. B., Moeller, H. C., Palmer, W. L. Polyps of the Colon and Rectum. J.A.M.A., 170:683, 1959.
3. Rider, J. A., Kirsner, J. B., Moeller, H. C., Palmer, W. L. Polyps of the Colon and Rectum: Their Incidence and Relation to Carcinoma. Am. J. Med., 16:555, 1954.
4. Jenson, C. B., Shahon, D. B., Wangensteen, O. H. Evaluation of Annual Examinations in the Detection of Cancer. J.A.M.A., 174:1783, 1960.
5. Freeman, G. C. Twenty-Five Hundred Proctoscopic Examinations. Ann. Surg., 26:431, 1960.
6. Kirsner, J. B., Rider, J. A., Moeller, H. C., Palmer, W. L., and Gold, S. S. Polyps of the Colon and Rectum. Gastroenterology, 39:178, 1960.
7. Grennell, R. S. and Lane, N. Benign and Malignant Adenomatous Polyps and Papillary Adenomas of the Colon and Rectum: An Analysis of 1856 Tumors in 1335 Patients. Internat. Abst. Surg., 106:519, 1958.
8. Wilson, G. S., Dale, E. H., and Brines, O. A. An Evaluation of Polyps Detected in 20,847 Routine Proctoscopic Exams. Am. J. Surg., 90:834, 1955.
9. Enterline, H. T., Evans, G. W. Mercudo-Lugo, R., Miller, L., and Fitts, W.T. Malignant Potential of Adenomas of Colon and Rectum. J.A.M.A., 179:322, 1962.
10. Turell, R. Diseases of the Colon and Anorectum, Vol 1, Chap. 17, Saunders.

11. Kohler, F. P. Asymptomatic Upper Urinary Tract Lithiasis in Flying Personnel, J. Urology, 65:370, 1961.

12. Ward, J. E., Hawkins, W. R., and Stallings, H. D. Physiological Response to Weightlessness: Initiation of Micturition. Aerospace Med., 30:572, 1959.

OTORHINOLARYNGOLOGY EVALUATION

Alfred Hamilton, Lt. Col., USAF, MC

Raymond O. Waters, Major, USAF, MC

Morgan E. Wing, Major, USAF, MC

Ward B. Litton, Captain, USAF, MC

Harrell C. Sutherland, Jr., M. Ed.

Roy Danford, Jr., B. A.

Robert L. Cramer, Ph. D.

Patrick J. Dowd, M. A.

1. INTRODUCTION

The scope of the otorhinolaryngological examination for space pilot candidates had its inception during the year prior to the performance of these examinations. During this time, professional members of the Otolaryngology Department formulated the plan of examination. Procedures which were considered to be necessary in an evaluation of this stature were carefully weighed as to aeromedical significance before being included in the orderly, systematic protocol.

2. CLINICAL EXAMINATION

Alfred Hamilton, Lt. Colonel, USAF, MC
Raymond O. Waters, Major, USAF, MC
Morgan E. Wing, Major, USAF, MC
Ward B. Litton, Captain, USAF, MC

The ear, nose and throat examination performed on space pilots and space pilot candidates is considerably more detailed and comprehensive than the routine ear, nose and throat evaluation. Certain procedures which are included in the usual examination only when specifically indicated or requested are carried out routinely on space pilots and space pilot candidates in order to maintain a consistent thoroughness among the various departments of the Clinical Sciences Division. These additional procedures help to provide a valid and reliable basis for comparison of candidates and establish sound criteria for selection or rating in the final aeromedical recommendation process.

As formulation of the space pilot examination progressed, it became apparent that a rating device (Table I), based on the overall ear, nose and throat examination, would be necessary in order that valid recommendations for acceptance or rejection of a candidate could be made. It was not the intent of the Otolaryngology Department to pre-emptorily disqualify any candidate, but rather to expend every effort to preserve the results of training, experience and monetary investment in each candidate. Even with this in mind, a disqualifying Category IV was required in the rating device to accommodate those individuals who fail to pass a Class I flying physical examination.

Otolaryngology Evaluation Protocol

The ear, nose and throat examination follows a consistent plan. The history is reviewed in detail with each candidate and "yes" answers in the Aeromedical Survey--System Review are used as guideposts in the performance of the physical examination accomplished immediately afterwards.

1. Medical History. Detailed inquiry is made of the following:

a. Ears -- History of infection, discharge, injury, hearing loss, tinnitus, pain, surgery, barotitis, exposure to noise, ototoxic drug intake and familial hearing loss.

b. Nose -- History of discharge, "post-nasal drip," obstruction, allergy, epistaxis, surgery, crusting or injury.

c. Sinuses -- History of sinusitis, acute or chronic, and

TABLE I

ENT space pilot rating device

ENT CATEGORY	STATE OF QUALIFICATION
I	Recommended. Best qualified
II	Qualified with reservation
III	Qualified
IV	Not recommended

treatment received. History of barosinusitis.

d. Mouth and Throat -- History of tonsillectomy and adenoidectomy, sore throat, quinsy, hoarseness, dysphagia or surgery.

e. Disorientation or Vertigo -- History of either of these conditions.

2. Physical Examination. With the otolaryngologic history in mind, the physical examination is carried out methodically and systematically, with special attention to the following:

a. Ears -- External ear, external canal, tympanic membrane, surgical scars, ability to Valsalva and evidence of middle ear pathology.

b. Nose -- External nose, septum, size and color of turbinates, polyps, discharge, obstruction, crusting and evidence of surgery.

c. Sinuses -- The frontal and maxillary sinuses are tested with the transilluminator.

d. Mouth -- Oral mucosa, tongue, salivary gland orifices and palate.

e. Oropharynx -- Tonsils, soft palate and posterior pharyngeal wall.

f. Nasopharynx -- Discharge, adenoids, other lymphoid tissue or masses, fossae of Rosenmueller, eustachian tube orifices and evidence of surgery. (This examination is performed with the electric nasopharyngoscope where the indirect method is ineffective.)

g. Hypopharynx and Larynx -- Lingual tonsils, valleculae, epiglottis, pyriform sinuses and vocal cords.

3. <u>Special Space Pilot Procedures.</u>

a. Tests of Vestibular Integrity

(1) Modified Kobrack Cold Caloric Test -- After inspection of the ear canal and tympanic membrane for evidence of abnormality, any accummulation of cerumen is removed and the ear canal is filled with ice water which is allowed to remain for 20 seconds. The head is then tilted so that the water drains out. A stop watch is started the moment ice water enters the canal and time is recorded when nystagmus is first observed in the face front position (head tilted backward so that the outer canthus of the eye is approximately directly above the external auditory meatus). Time is again recorded upon cessation of nystagmus while the head is in this position. The plane, direction, frequency and amplitude of the nystagmic response, presence or absence of vasomotor reaction, and presence of past pointing and falling tendency is noted. An interval of at least 10 minutes is allowed to elapse before the opposite ear is tested in the same manner.

(2) Labyrinthine reaction to bi-axial stimulation -- The unusual situation of prolonged weightlessness during extended space flight when proprioceptive cues are minimal or absent presupposes greater dependence upon the vestibular system for maintenance of spatial orientation and necessitates inclusion of this test of vestibular integrity. More detailed information is contained in the vestibular examination section of this chapter.

b. X-ray Examination of the Paranasal Sinuses -- This is a routine procedure in the space pilot evaluation. The presence of acute or chronic sinusitis, allergic rhinosinusitis, nasal polyps, or polypoid degeneration of paranasal sinus mucosa is disqualifying for conventional flying duties and therefore is considered so in space pilots, even if asymptomatic. On the other hand, the asymptomatic sinus cyst or mucocele which does not encroach upon the natural sinus ostium is not aeromedically significant.

c. Audiometric Testing -- The testing of a space pilot candidate's ability to hear and understand difficult speech from recorded material is performed routinely, notwithstanding normal threshold, pure tone audiometry. The space pilot must rely strongly upon his ability to hear and understand verbally communicated directions in the presence of noise and vibration of considerable magnitude, particularly during certain phases of flight. The problem of noise and vibration can be expected to become more important as greater power booster systems are utilized. More detailed discussion of audiometric testing is contained in the audiology examination section of this chapter.

Results and Final Recommendations

Four of the 32 candidates evaluated were placed in Category IV (See Table II) and this resulted in a negative recommendation for their participation in the space pilot program. This recommendation was made because of physical findings which are disqualifying for Class I flying, according to the standards of Air Force Manual 160-1. Based on our best judgment, selection of these candidates would have compromised future monetary and training investment. One of these four candidates had clinically manifest otosclerosis, which is known to

TABLE II

Distribution of 32 successive candidates by ENT space pilot rating device

ENT CATEGORY	EXAMINATION FINDINGS	NR. IN GROUP
I	Negative physical findings	18
II	Mild, high frequency deafness; mild, asymptomatic deflection of nasal septum.	6
III	Moderate, high frequency deafness; minor, asymptomatic physical findings.	4
IV	Moderate to severe deafness, paranasal sinusitis, otosclerosis	4

progress at an unpredictable rate and sometimes becomes bilateral. One candidate was found to have x-ray evidence of chronic thickening of the mucosa of the left maxillary antrum and a rounded radio-opaque density resembling a cyst in the right maxillary antrum. Another candidate had chronic non-purulent disease of the left maxillary antrum. The fourth candidate not recommended for final selection was discovered to have polypoid degeneration of the mucosa in the middle nasal meati and an x-ray finding of marked thickening of the mucosa in the left maxillary antrum.

Four of the 32 candidates evaluated were placed in Category III because of a high frequency hearing loss with borderline impairment of speech discrimination and/or the finding of aeromedically insignificant abnormalities, such as a small cyst of the paranasal sinuses.

Six of the 32 candidates evaluated were placed in Category II because of lesser degrees of high frequency hearing loss, but normal speech discrimination scores.

Eighteen of the 32 candidates evaluated were found to have no physical abnormality of the ears, nose and throat, and demonstrated normal auditory and vestibular function.

3. AUDIOLOGY EXAMINATION

Harrell C. Sutherland, Jr., M. Ed.
Roy Danford, Jr., B. A.

The audiological evaluation consists of a series of four audiometric tests given to each candidate. The tests are pure tone air conduction (AC) threshold, pure tone bone conduction (BC) threshold, speech reception threshold (SRT) and speech discrimination (PB Max).

The tests are all administered with a single auditory test unit feeding an anechoic chamber in which the subject is seated. All tests are done monaurally through TDH-39 earphones for air conduction and through a hearing aid type vibrator for bone conducted pure tone.

Pure tone air conduction threshold testing is done at frequencies 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 cycles per second (cps). Individual thresholds are obtained using the revised Hughson-Westlake technique (9). Levels recorded are the least intense levels at which the subject responds to the tone presentations. The recorded levels are in decibels (db) reference American Standards Association audiometer zero, which is the average threshold found in a large sample of individuals free from hearing pathology (11). The AC threshold pattern provides an estimate of ability to hear and understand speech, serves to detect the presence of hearing loss not yet noticed by the individual and also assists in determining the site of lesion if hearing loss is present. The range of "normal" hearing -- from approximately -10 db to about 15 db -- results in a degree of scaling within a normal hearing population (11, p. 178).

The frequencies 500, 1000 and 2000 cps are considered the most important for hearing and understanding speech. The thresholds for these three frequencies are averaged for each individual and the result is reported as the speech frequency average (SFA).

Pure tone bone conduction threshold testing, in conjunction with AC testing, is designed to provide a measure of the efficiency of the mechanical pathways of air conducted sound from the tympanic membrane to the oval window of the cochlea. The BC test is done by placing an oscillator on the mastoid process of the test ear so that pure tones are delivered to the cochlea by vibration of the skull, thus bypassing the route for air conducted sound through the outer and middle ear. Thresholds are determined in the same manner as in AC testing and levels recorded are again in decibels -- reference normal hearing. An impairment of the AC mechanical sound pathways will result in better hearing by BC. The degree of difference between AC and BC, and the pattern of difference by frequency, is helpful in determining pathology such as otosclerosis and chronic otitis media (7).

Speech reception threshold is a measure of the least intense level at which simple spondaic words are heard and understood. Reported thresholds are in decibels -- reference normal hearing. The standard commercial Central Institute For The Deaf (CID) auditory test W-1 (14), lists A and B, are used to make the SRT measurements. The material on disc recordings is delivered through the auditory test unit and the thresholds obtained agree very closely with the SFA found in pure tone AC testing. Any discrepancy is evidence of either poor test validity or serious auditory disorder (8, 16).

Speech discrimination testing is designed to determine understanding for difficult speech presented at a level 40 db more intense than the SRT. The score recorded for each ear is the percentage of words from a 50 word list which is repeated correctly. The 50 words are phonetically balanced (PB) so that the sounds of American speech occur at the same frequency by position in the words as they occur in normal conversational speech (12). The commercial recordings of the Harvard PB-50, lists 7 and 8, are used for all subjects. These particular recordings use Rush Hughes as the speaker and they provide one of the most difficult discrimination tests in current use, yielding normal scores of about 80 percent. Lesions such as significant cochlear damage or impairment of the eighth cranial nerve typically result in dramatically reduced speech discrimination scores. The primary value of the PB Max test is in assisting the determination of site of lesion in cases having pure tone hearing loss as well as in those cases demonstrating more subtle hearing difficulties not evidenced in other tests. The difficult nature of the word lists results in some degree of scaling among normal hearing persons.

Audiologic Results

The figures and tables included in this section summarize auditory tests done on 30 successive space pilot candidates. The pure tone AC threshold data tabulated in Table III for the right ears and Table IV for the left ears, show the scatter of results within this group of subjects. Three measures of central tendency (mean, median and mode) are also presented; all three were included since any one alone might be misleading. These same measures are also illustrated graphically in Figures 1 and 2. In order to visually portray the scatter of results, the total range of pure tone AC thresholds for these 30 candidates has been graphed in Figures 3 and 4. The bone conduction threshold results for these same listeners are reported in Tables V and VI. The minor differences between AC and BC thresholds can be primarily attributed to error of measurement and calibration deviation (7, 15). One candidate showed evidence of a mild conductive impairment in one ear.

TABLE III

Distribution, mean, median and mode of right ear pure tone air conduction thresholds for 30 space pilot candidates

	Frequencies							
Decibels	250	500	1000	2000	3000	4000	6000	8000
-10	28	21	15	10		1		10
-5	2	8	13	15	4	5	3	5
0		1	2	4	9	6	1	1
5					9	5	3	2
10					4	2	6	1
15						2	2	4
20				1		1	2	
25					1	2	5	
30					1	1		2
35						1	1	1
40						1	1	2
45					1	1	1	1
50							2	
55					1	2	1	1
60								
NR							2*	
Mean	-9.33	-8.33	-7.16	-5.16	7.33	12.33	21.66	7.66
Median	-9.8	-8.9	-7.5	-5.8	3.6	5.5	17.5	-2.5
Mode	-10	-10	-10	-5	2.5	0	10	-10

* Threshold not measurable. Hearing poorer than 60 db limits of equipment.

TABLE IV

Distribution, mean, median and mode of left ear pure tone air conduction thresholds for 30 space pilot candidates

	Frequencies							
Decibels	250	500	1000	2000	3000	4000	6000	8000
-10	25	22	19	9	1	1		10
-5	4	4	6	10	2	2	1	5
0	1	2	2	7	8	3	2	
5		1	2	2	8	5	4	1
10				1	1	5	1	5
15				1	3	2	4	2
20		1	1		2	2	3	2
25						2	3	1
30					2	3	2	1
35								
40					2	2	2	1
45							1	
50						2	1	
55					1		1	
60						1	1	
NR							4*	2*

* Threshold not measurable. Hearing poorer than 60 db limits of equipment.

	250	500	1000	2000	3000	4000	6000	8000
Mean	-9.00	-7.16	-6.33	-3.50	10.33	16.83	27.00	7.16
Median	-9.5	-9.1	-8.6	-4.5	5.0	11.5	22.5	0
Mode	-10	-10	-10	-5	2.5	7.5	10	-10

TABLE V

Distribution, mean, median and mode of right ear pure tone bone conduction thresholds for 30 space pilot candidates

	Frequencies					
Decibels	250	500	1000	2000	3000	4000
-10	9	17	5	5	2	
-5	16	10	11	8	1	
0	4	3	13	11	9	2
5	1		1	5	10	9
10					5	7
15						
20						3
25				1		1
30						1
35					1	2
40					1	1
45						1
50						1
55						
60					1	1
NR						1*

* Threshold not measurable. Hearing poorer than 65 db limits of equipment.

Mean	-5.50	-7.33	-3.33	-1.33	7.00	18.66
Median	-5.6	-8.1	-3.0	-1.6	4.5	10.4
Mode	-5	-10	0	0	5	5

TABLE VI

Distribution, mean, median and mode of left ear pure tone bone conduction thresholds for 30 space pilot candidates

	Frequencies					
Decibels	250	500	1000	2000	3000	4000
-10	18	19	7	2	2	
-5	9	8	12	11	3	1
0	2	2	8	10	7	2
5	1	1	3	4	4	3
10				2	4	6
15				1	4	5
20					1	1
25					2	2
30					1	3
35					1	2
40						1
45						1
50						
55						
60						2
65					1	
NR						1*

* Threshold not measurable. Hearing poorer than 65 db limits of equipment.

Mean	-7.33	-7.50	-3.83	-0.66	9.50	21.50
Median	-8.3	-8.6	-4.1	-1.5	6.3	15.5
Mode	-10	-10	-5	-5	0	10

The average pure tone hearing level for the frequencies 500, 1000 and 2000 cps -- the SFA -- is in close agreement with the SRT, indicating good inter-test consistency and validity (See Table VII). In addition, this table shows that as a group, these subjects had hearing which is superior to that of average normal listeners. The poorest SFA and SRT in this group was exhibited by the one subject possessing a conductive hearing impairment. The PB Max scores are nearly all within the range of high normal values, with no scores indicative of serious pathology of the hearing mechanism.

Median pure tone AC thresholds for the 30 space pilot candidates were contrasted with a comparable age group of Air Force pilots (See Figures 5 and 6). This population of Air Force pilots received hearing evaluations at the USAF School of Aerospace Medicine from 1955 through mid-April 1963 (13). The median hearing levels for the two groups are very similar, with the most noticeable difference occurring at 6000 cps where the space pilots show somewhat poorer hearing.

Pure tone AC thresholds for two space pilot candidates not included in the above reporting are as follows:

	250	500	1000	2000	3000	4000	6000	8000	SFA
Nr. 1									
Right:	-10	-10	-5	-10	0	5	-5	-5	-8
Left:	-10	-10	-10	-5	-5	0	-5	-5	-6
Nr. 2									
Right:	-10	-10	-10	-5	5	5	15	0	-8
Left:	-10	-10	-10	0	5	5	0	0	-6

TABLE VII

Distribution, mean, median and mode of speech frequency average (SFA), speech reception threshold (SRT) and speech discrimination (PB Max) for right and left ears of 30 space pilot candidates

	SFA		SRT	
Decibels	Right	Left	Right	Left
-10	7	5		
-9			2	
-8	9	10	3	4
-7			3	5
-6	3	4	8	5
-5	7	5	8	6
-4			2	2
-3	3	1	2	2
-2			1	3
-1		2		
0			1	
1	1	2		
2				1
3				1
Poorer Than 3		(18)		(21)
Mean	-6.76	-5.46	-5.56	-4.03
Median	-7.6	-7.0	-5.6	-5.3
Mode	-8	-8	-5.5	-5

	PB Max	
Percent	Right	Left
94		
92	2	1
90	5	
88	4	7
86	7	7
84	6	5
82	2	5
80	2	1
78	1	
76		2
74	1	
72		
70		1
68		1
Mean	85.60	83.66
Median	85.9	85.0
Mode	86.0	87.0

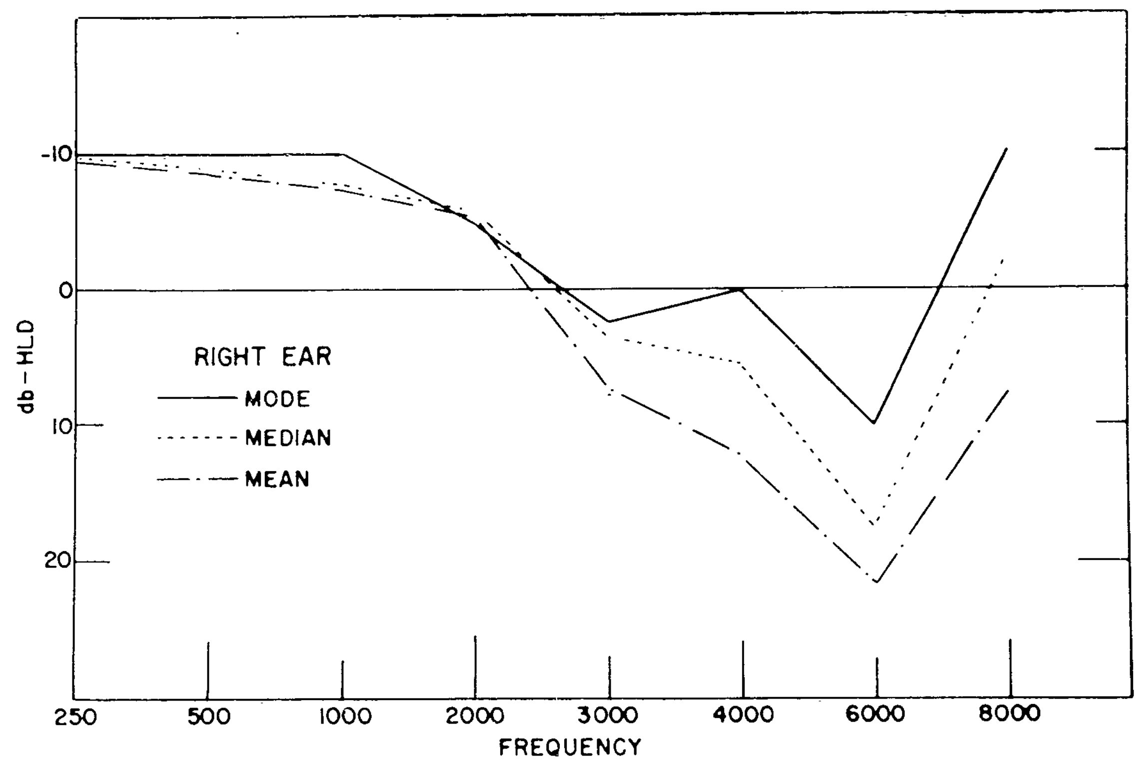


FIGURE 1

Mean, median and mode of right ear pure tone air conduction thresholds for 30 space pilot candidates.

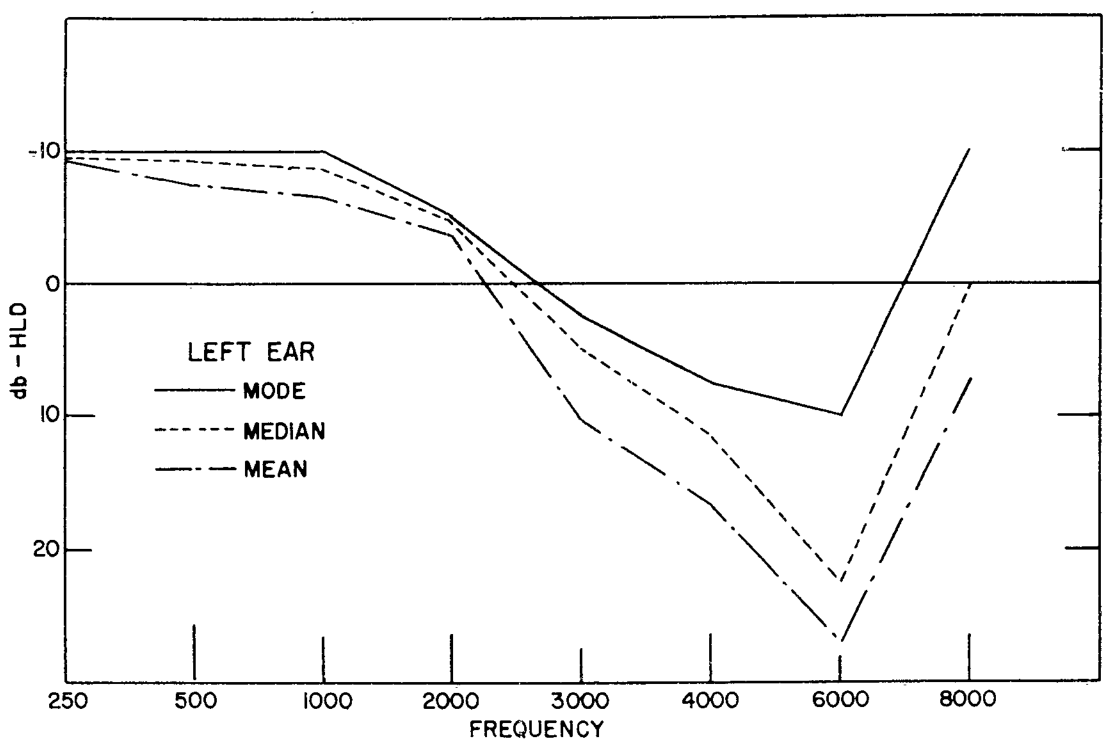


FIGURE 2

Mean, median and mode of left ear pure tone air conduction thresholds for 30 space pilot candidates.

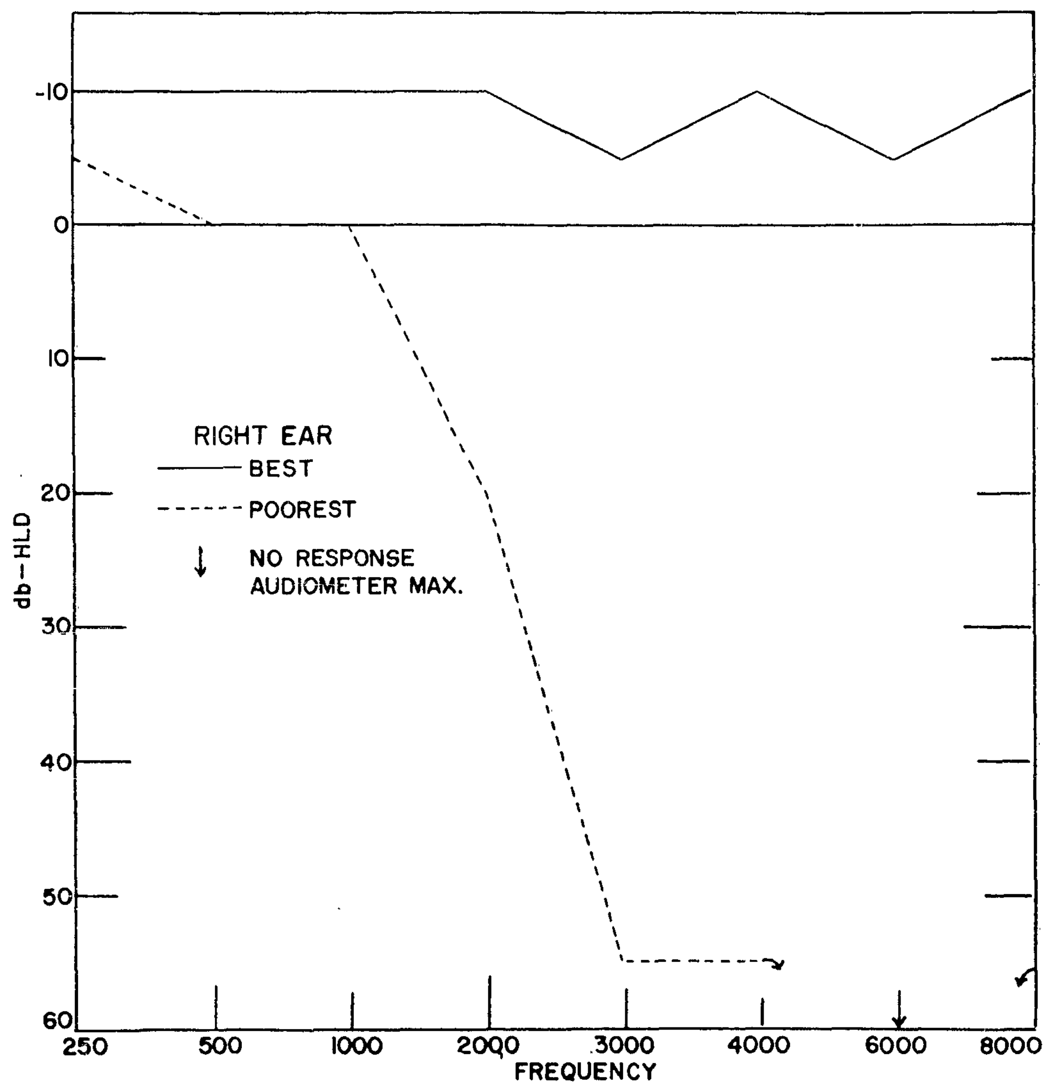


FIGURE 3

Range of right ear pure tone air conduction thresholds for 30 space pilot candidates.

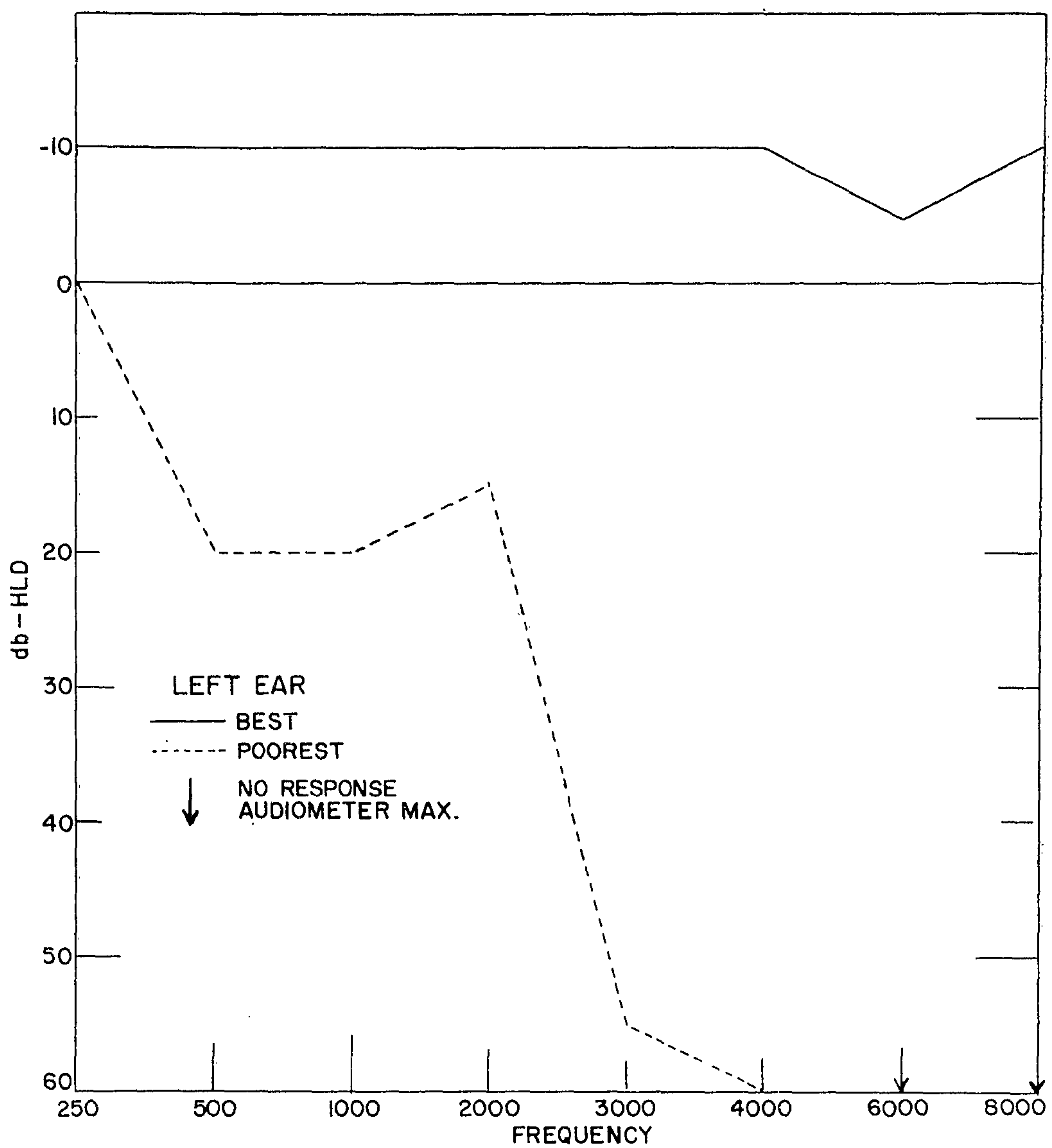


FIGURE 4

Range of left ear pure tone air conduction thresholds for 30 space pilot candidates.

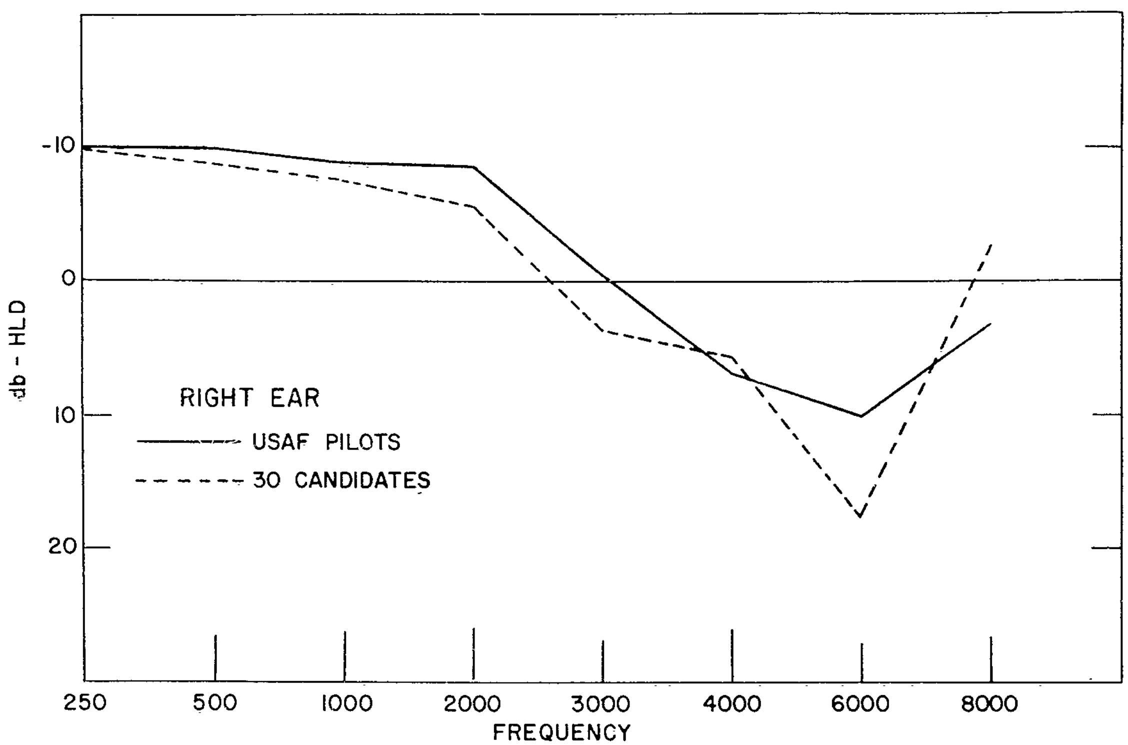


FIGURE 5

Median right ear pure tone air conduction thresholds for 30 space pilot candidates and for another comparable age group of Air Force pilots.

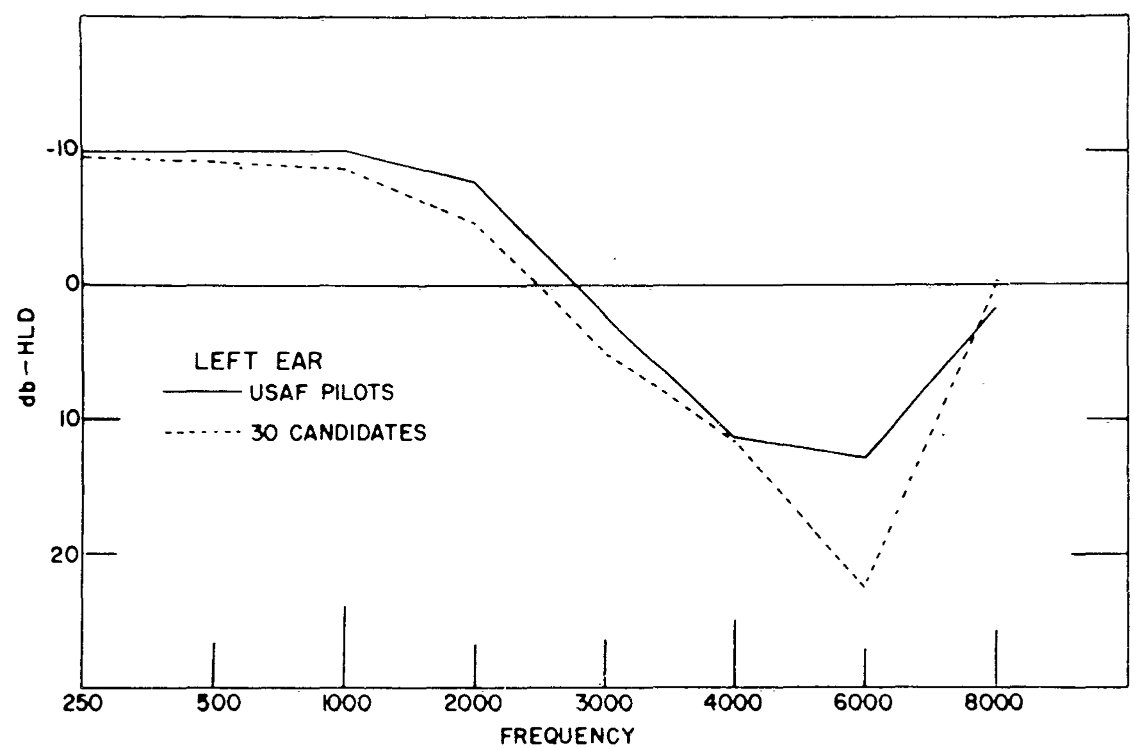


FIGURE 6

Median left ear pure tone air conduction thresholds for 30 space pilot candidates and for another comparable age group of Air Force pilots.

4. VESTIBULAR EXAMINATION

Robert L. Cramer, Ph. D.
Patrick J. Dowd, M. A.

Dynamic vestibular stimulation is accomplished on a bi-axial stimulator for the purpose of determining the degree to which each candidate has become conditioned against spatially disorienting and otherwise disturbing vestibular stimuli as a result of previous repetitive exposure to linear, gravitational, angular and radial acceleration, such as is anticipated in space operations.

Conventional flight and space operations frequently impose angular velocities upon the aircrew. These can be deliberately induced, as in maneuvering, simulated gravity satellites, etc., or they may be caused by atmospheric conditions, lack of stabilizing systems or improper selection of stabilizing systems which results in the vehicle hunting or oscillating about some axis. The axis of rotation may pass through the vehicle or be some distance from it.

Changing the angular relationships between the head and the axis of rotation results in false perceptions of position and/or movement, changes in posture, and visceral disturbances, as in the case of Cosmonaut Titov. These responses change in amplitude and duration if the stimuli are presented repetitively over successive days in the laboratory (18, 19), or if the stimuli are presented repetitively in flight operations (20). Lateral tilting of the head while rotating at a fixed velocity about a vertical axis produces among other responses a vertical nystagmus which outlasts the stimulus. This response can be described quantitatively. Repetitive stimulation over a number of days in a conditioning program causes a reduction in the amplitude of the response and an increase in the rate of growth and decay of the response (17) (Figure 7). Electronystagmograms of the space pilot candidates will be compared with the "conditioned" nystagmograms. The testing procedure is as follows.

Silver EEG disc electrodes are mounted at the acanthi and on the forehead between the eyebrows. The candidate is seated in the chair and instructed not to change the position of his head and body in the chair, to refrain from blinking or talking and to relax. His head is placed in a specially constructed pillow in order to minimize head movements and two body straps are tightened across his thighs and his chest. The chair is tilted about an axis through the sternum to approximately 30 degrees from the vertical. Lights are turned out and the room is sealed against light leaks. The chair is rotated in a clockwise direction for 2 minutes at 19 rpm, then the candidate is tilted about the sternal axis through the vertical to 30 degrees on the opposite side (Figure 8). This tilt is accomplished in 3 seconds. After 2 minutes, the candidate is tilted back to his original position, etc., until a total of eight tilts is accomplished.

The candidate is observed after the test for signs of motion sickness (sweating, pallor, compulsive swallowing, etc.) and is queried as to his sensations of movement and any discomfort. Electronystagmograms are analyzed for the rate of the slow phase deviations after the tilt. Logarithms of these rates are plotted against time and the dynamic characteristics of the vestibulo-ocular reflex arc are

FIGURE 7

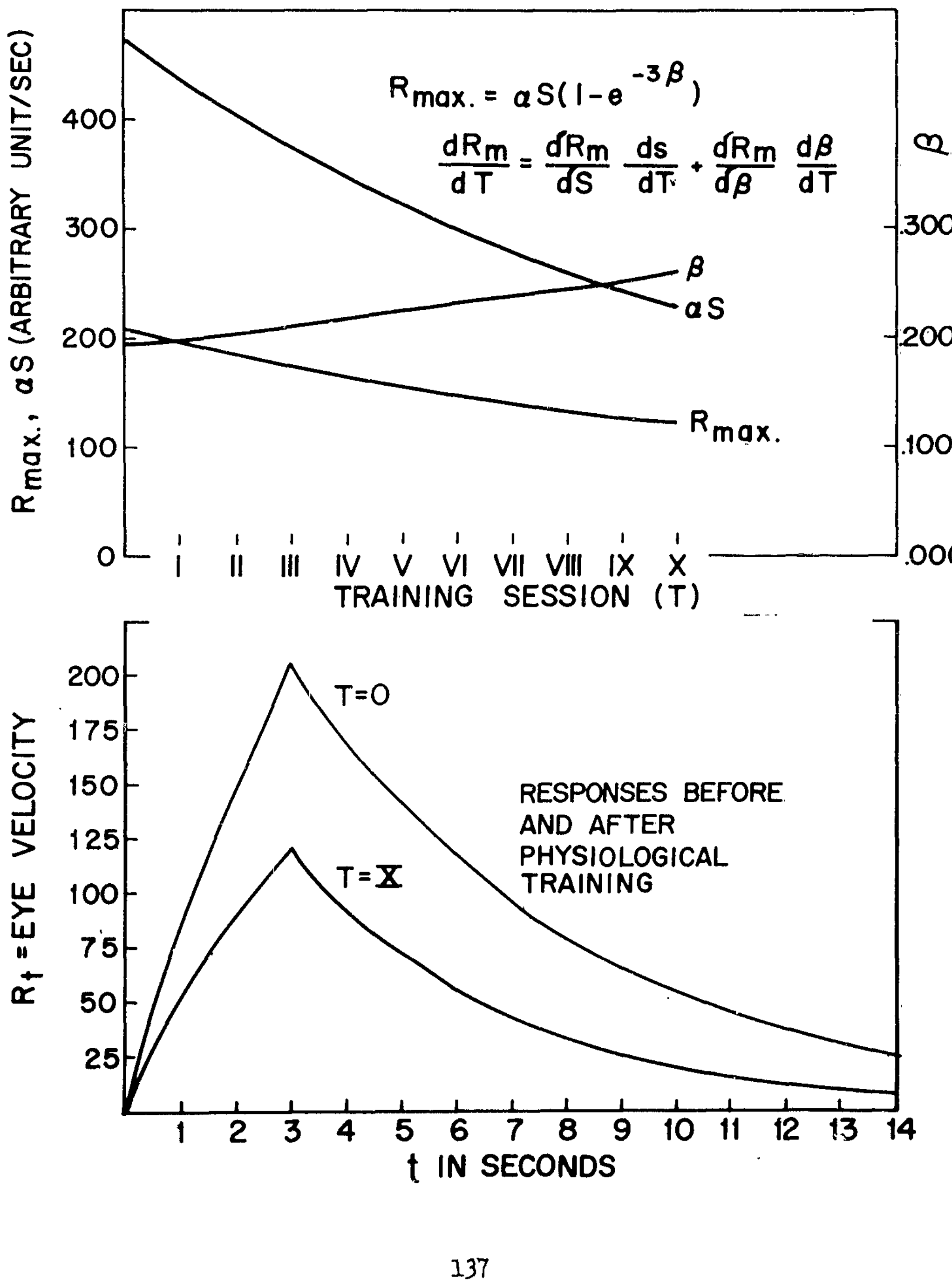
Upper: Parameters of the vestibulo-ocular reflex arc as deduced from the slow phase velocity of the nystagmus which follows a Coriolis stimulation of three seconds duration.

Lower: Theoretical nystagmic response during (0-3 sec.) and following Coriolis stimulation (3-14 sec.). T = 0, response of the unconditioned subject; T = X, response after 10 conditioning periods. These curves were drawn from the equations

$$R_t = \alpha S(1-e^{-\beta t}), \text{ for } t \leqslant 3 \text{ sec., and}$$

$$R_t = \alpha S(1-e^{-3\beta})e^{-\beta(t-3)}, \text{ for } t \geqslant 3 \text{sec.}$$

PHYSIOLOGICAL CONDITIONING OF THE VESTIBULAR SYSTEM



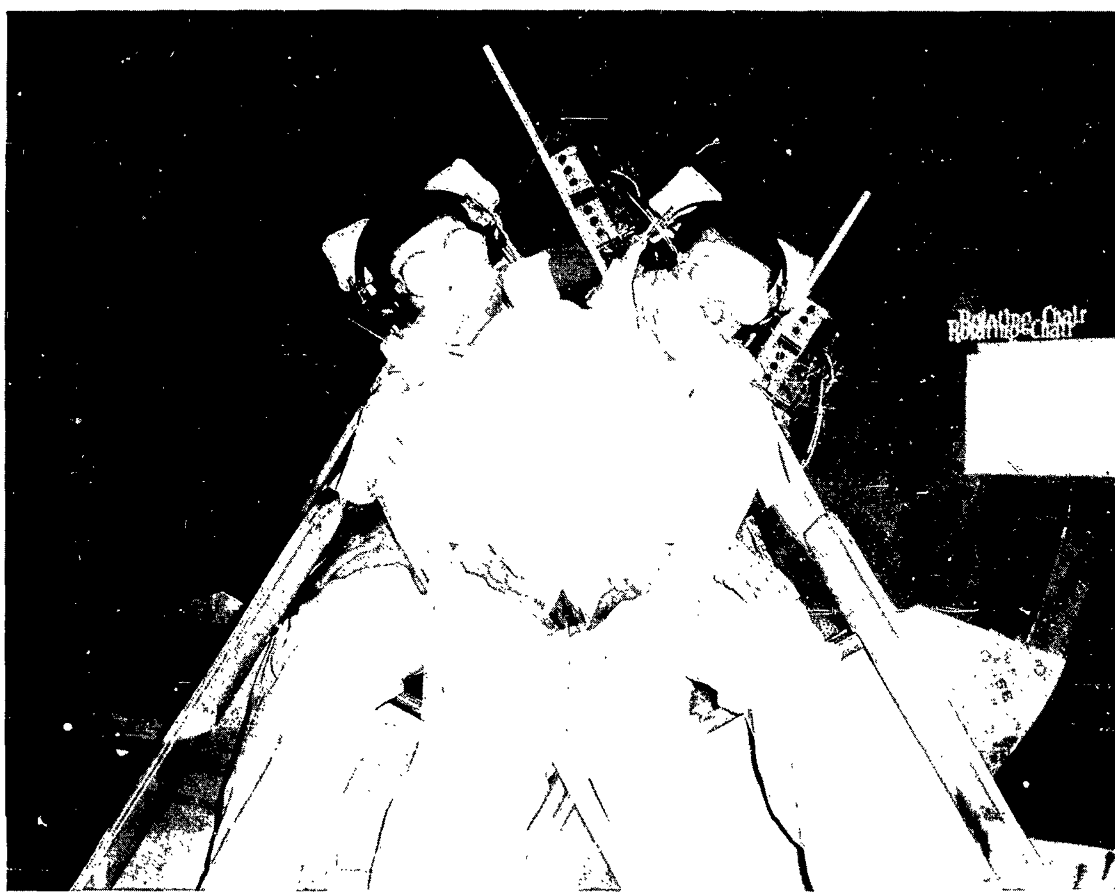


FIGURE 8

Double exposure of subject in rotating tilt chair, showing the two extremes of tilt.

determined from the best fitting straight line on this plot. The sensitivity of the system is computed from the dynamic characteristic and the maximum eye velocity according to the function:

$$\alpha S = \frac{R_{max}}{(1 - e^{-3\beta})}$$

Candidates are judged for their resistance to disorientation primarily on the basis of the two parameters determined from their nystagmograms (sensitivity and dynamic characteristics) and secondarily upon regularity of the nystagmus, their sensations of movement, and observed or reported autonomic responses. The ideal candidate shows a low sensitivity (S) and a high value for the exponent β , and reports no sensations of movement or sensations that are mild and of short duration.

None of the candidates became sick to the point of vomiting, although a number of them were pale and sweating at the end of the test and reported a sensation of nausea which persisted between tilts. Those whose nystagmic and perceptual responses showed them to be highly qualified, frequently reported a slight epigastric awareness that occurred during tilt only. Because of the low intensity of this response and the rapid recovery, it is doubtful that this epigastric awareness is significant from an aeromedical point of view. Indeed, this sort of response could be interpreted as an indication that the candidate has had considerable experience with disorienting vestibular stimuli and has, in fact, become advantageously conditioned to them.

For data collecting purposes, a vestibular rating system was utilized to indicate the degree of conditioning found and the candidates were separated into five categories according to their test responses:

Category 1 -- Fly now.

Category 2 -- Probable or fly now (a couple of days of conditioning in the vestibular chair should place them in Category 1)

Category 3 -- Probable (a week or two of conditioning in the vestibular chair could place them in Category 1)

Category 4 -- Possible (unable to determine at this point. There is nothing to indicate that they could not be prepared for flight)

Category 5 -- Questionable (test was so disrupted in one way or another that results are doubtful. They might be conditioned, but they should be the last ones selected for flight)

5. SUMMARY

The otorhinolaryngology examination for space pilots is considerably more detailed and comprehensive than the routine ear, nose and throat evaluation and includes an item by item medical history, a methodical and systematic physical examination, tests for vestibular integrity (cold caloric test and labyrinthine stimulation by bi-axial rotation), and complete audiometric testing. The 32 space pilot candidates examined impressed the professional staff of the Otolaryngology Department as being the most eager, highly motivated individuals they have had the pleasure of evaluating. An ear, nose and throat rating device based on the overall examination was utilized in classifying the candidates and of the 32 examined, only 4 or 12.8 percent of them could not be recommended for continued space pilot training. The major factors resulting in recommendation for disqualification were moderate to severe deafness, paranasal sinusitis and otosclerosis.

ACKNOWLEDGMENTS

Appreciation is expressed to: Staff Sergeant James E. Plowden for assistance in the performance of the clinical physical examination; to Airman First Class John D. Beuchler who assisted in tabulation and analysis of auditory test results; and to Airmen First Class Donald B. Helms and James C. Sanders for technical support in accomplishing the vestibular rotational testing with the bi-axial stimulator.

REFERENCES

1. Jackson, Chevalier, and Chevalier L. Jackson. Diseases of the nose, throat, and ear. Philadelphia:W. B. Saunders, 2nd ed., 1959.
2. Coates, George M., Harry P. Schenck, and M. Valentine Miller. Otolaryngology. Hagerstown, Md.:W. F. Prior Co., Inc., 1960 (As revised in part in 1962).
3. Boies, Laurence R. Fundamentals of otolaryngology. A textbook of ear, nose and throat diseases. Philadelphia:W. B. Saunders, 3rd ed., 1959.
4. Lederer, F. L. Diseases of the ear, nose and throat. Philadelphia: F. A. Davis Co., 6th ed., 1952.
5. Morrison, William W. Diseases of the ear, nose and throat. New York:Appleton-Century-Crofts, Inc., 2nd ed., 1955.
6. McNally, W. J., and E. A. Stuart. Examination of the labyrinth in relation to its physiology and nonsuppurative diseases. Am. Acad. Ophth. & Otolaryng. Home Study Course Manual, 1953.
7. Carhart, R. Clinical application of bone conduction audiometry. A. M. A. Arch. Otolaryng. 51:798-808 (1950).
8. Carhart, R. Speech audiometry in clinical evaluation. Acta Otolaryng. 41:18-42 (1952).
9. Carhart, R., and J. F. Jerger. Preferred method for clinical determination of pure tone threshold. J. Speech Hearing Dis. 24:330-345 (1959).
10. Davis, H., and R. S. Silverman. Hearing and deafness. New York: Holt, Rinehart and Winston, Inc., 1960.

11. Davis, H., and J. R. Usher. What is zero hearing loss? J. Speech Hearing Dis. 22:662-690 (1957).

12. Egan, J. P. Articulation testing methods. Laryngoscope 58:955-991 (1948).

13. Elliott, Lois L. Hearing of Air Force pilots: 1955-1962. USAF School of Aerospace Medicine Technical Documentary Report 62-127, December 1962.

14. Hirsh, I. J., H. Davis, S. R. Silverman, E. G. Reynolds, E. Eldert and R. W. Benson. Development of materials for speech audiometry. J. Speech Hearing Dis. 17:321-337 (1952).

15. Jerger, J., and T. Tillman. A new method for the clinical determination of sensori-neural-acuity level. USAF School of Aerospace Medicine Report 60-31, January 1960.

16. Juers, A. L. Pure tone threshold and hearing for speech-diagnostic significance of inconsistencies. Laryngoscope 66:402-409 (1956).

17. Cramer, R. L., P. J. Dowd, and E. W. Moore. Changing parameters in the habituating vestibular system. (Manuscript in preparation)

18. Cramer, R. L., P. J. Dowd, D. B. Helms, and E. W. Moore. The vestibulo-ocular reflex arc. II. Changes in the sensitivity and dynamic characteristics induced by habituation to simple harmonic motion. (Manuscript in preparation)

19. Graybiel, A., F. E. Guedry, U. H. Johnson, and R. S. Kennedy. Adaptation to bizarre stimulation of the semicircular canal as indicated by the oculogyral illusion. J. Aerospace Med., 32:321 (1961).

20. Kraus, R. N. Evaluation of a simple Coriolis test for vestibular sensitivity. J. Aerospace Med., 31:852 (1960).

OPHTHALMOLOGY EVALUATION

William B. Clark, Capt., USAF, MC

Sanford L. Severin, Capt., USAF, MC

James F. Culver, Lt. Col., USAF, MC

INTRODUCTION

Prior to the date of these examinations, the Ophthalmology Department began the formulation of plans for examinations and criteria for selection recommendations of space pilots. Since then, there have been successful manned space flights, requiring a high degree of visual responsibility and confidence. This trend has continued through Commander Schirra's flight and will undoubtedly continue in future space missions.

The increasing reliance on vision is important to mission accomplishment because it will allow a relative payload increase by reducing electronic and automatic visual back-up systems. The future space crew members' visual function may also assume a vital military role and will certainly undergo more severe stresses than any experienced in the past. As the duration and complexity of the missions increase, there will be new extremes of tension and boredom, of vibration and high G's, and of illumination from dazzling sunlight to subtle starlight. There will also be periods of casual "looking around" followed by swift and critical shifts between near and distant gaze when rendezvous or visually controlled re-entry is effected. All of these extremes will become more and more repetitive, and the sustaining of visual function through them will be more critical as the complexity of space missions increases.

The ophthalmologist's function in examining future space crew members is to help in assuring that their visual capabilities are excellent and will continue to be so for several years.

DISCUSSION

General Medical Considerations of the Eye Examination

In establishing the procedures to be utilized in an eye examination of this special type, we were able to exercise an extreme degree of flexibility. No administrative limits were set on time, number of procedures or expense. Within this free framework we were able to utilize our entire department for support and were thus capable of performing an examination which, as perfectly as is practical, would accomplish the following functions:

1. Rule out active subclinical disease processes.
2. Rule out early asymptomatic dystrophic diseases and the glaucomas. This amounts to establishing that the man is free of predictable future incapacity from disease.
3. Rule out present and predictable future incapacity from "normal" causes, such as hyperopia or heterophoria.

4. Establish the present visual capabilities at normal light levels and at the extremes of illumination.

5. Establish baseline data for future follow-up.

The general purpose of the examination was, therefore, the documentation of the candidates' present and predictable future visual capability, thus assuring the best quality of visual input. This high quality is felt to be of great importance to the achievement of maximum utilization of men in space.

Administrative Considerations

Previous daily experience with similar examinations for the USAF flying population had shown us the time requirements for various procedures. These requirements are listed in Attachment I. The final scheduling arrangement worked extremely well and resulted in interdepartmental efficiency and minimal patient delays.

During the examinations a check list (Attachment 2) was maintained. This was designed to be certain that all details of the examination were completed on each patient.

Our own examination forms (Attachment 3) were used by the physicians and technicians for data accumulation. These are the same forms which we have used on all our aeromedical examinations. Form 0-47 was retained in our files as a "work copy." The final report (Attachment 4) on each man consisted of the following four parts: 1) a narrative summarizing our opinions concerning the overall ocular health and quality of visual function; 2) a table of the baseline values and findings; 3) the visual field results; and 4) fundus photographs.

After the completion of all of the examinations, the data which we considered to be most important in relation to space operations were tabulated. With this tabulation the candidates were ranked and grouped into three categories: 1) Best qualified. 2) Qualified without reservation. 3) Qualified with reservations. As will be shown later, there was no necessity for a fourth group: Disqualified.

Rationale and Methods for Ophthalmologic Examination Procedures

All tests were procedures with well established normal values and with which our examiners could claim competence. The candidates were not utilized as experimental subjects. The most important test had been performed prior to our examination -- an "in-flight visual effectiveness test." The mere fact that each candidate was an experienced test pilot constituted this test, and was considered to be an important aeromedical fact in attesting to his current visual effectiveness.

Beyond this informal "test," we attempted to obtain observations and data which would meet the five objectives outlined under "General Medical Considerations of the Eye Examination," as discussed above.

We have grouped these procedures under four general headings:

1. "Positive Normal" Observations
2. Visual Function Data
3. Extraocular Muscle Coordination
4. Intraocular Dynamic Function

We will now consider the rationale for the tests in each of these groups:

1. "Positive Normal" Observations

In the examination of sick patients a "positive" finding is evidence of disease or abnormality. In the practice of "aerospace ophthalmology" we must deal primarily with individuals who are symptom-free. A large share of our medical effort is expended in seeking "positive normal" findings which rule out the early stages of diseases which could later result in visual incapacity. In a broad sense, our entire examination could be considered under this heading, but for discussion purposes we limit this to a group of observations which are not reducible to numbers or measurable in any real sense.

This group of "positive normal" findings is sought in the course of ophthalmoscopy, slit lamp biomicroscopy, and gonioscopy. In ophthalmoscopy, for example, we seek the tiny foveal light reflex produced by the concavity of the fovea centralis. The presence of this concavity gives fair assurance of the structural integrity of this all-important region. In biomicroscopy, the demonstration of a normal mosaic pattern of the corneal endothelium eliminates consideration of an early corneal dystrophy, and the "beaten silver" appearance of posterior lens capsule reflection rules out early nuclear sclerosis and posterior subcapsular cataract. The gonioscopic visualization of scleral spur and ciliary body in the periphery of the anterior chamber angle rule out congenital or acquired defects which could compromise the outflow of aqueous humor and result in glaucoma.

These are a few examples of the "positive normal" observations which we sought. Their presence has obvious implications in terms of ruling out predictable visual incapacity and therefore in helping to assure the safety of the training investment for space crew candidates.

2. Visual Function Data

The tests included in this group are as follows: visual acuity, near and distance, monocular and binocular; night vision at scotopic levels; photostress test (time for recovery of acuity under conditions of partial dark adaptation followed by an intense light flash exposure); color vision; stereopsis; and central and peripheral visual fields.

The visual acuity was tested in a standard 20 ft. eyelane. A "projecto chart" was used which made available the display of letters of 20/15, 20/12.5 and 20/10 size. Binocular and monocular acuity was tested at 20 in. and at 20 ft. A Snellen metric card was used for the 20 in. tests.

Photostress testing utilized a specially modified Zeiss Photocoagulator as the light source. Following each of three pre-calibrated flash exposures, the time required for readaptation to a low level of light (equivalent to night cockpit illumination) was determined. The recovery target consisted of a Landolt "C" presented in a Goldman-Weekers adaptometer. The details of this procedure can be found in another article (1). This procedure simulates the experience in space of unexpectedly encountering the sun at a time when spacecraft instruments must be monitored.

Visual fields were performed as a baseline and diagnostic test in the standard manner using tangent screen and perimeter. The details of test object size and distance can be found in Attachment 4, a sample of one of the normal examinations.

Night vision, color vision, and stereopsis were performed in strict accordance with the current AF Manual 160-1, extracts of which are found in Attachment 5.

These tests and measurements all result in recordable charts, curves, or numbers which afford us an overall picture of the integrity of structures and functions which are not visible to the examiner:

cones, rods, nerve fibers, brain tracts and brain cortex. All of these results were reported on the final chart and thus will serve as baseline data for future follow-up on the selected candidates.

3. Extraocular Muscle Coordination

A battery of muscle function tests was performed which included the following: cover test, fusional amplitudes (or vergence amplitudes), gross observation of ductions and versions, near point of convergence, red lens test, and heterophoria measurement.

The cover test was done in the primary position at near and distance and in the six cardinal directions at near. Thus it served as an objective validation of red lens test results and subjective heterophoria measurement.

The fusional amplitudes (often referred to as "vergence amplitudes") included both horizontal and vertical vergence testing at 20 ft. and at 20 in. This latter distance was chosen in preference to the more usual 13 in. testing because it more closely simulates the working distance for near vision. Horizontal vergences were tested using a 20/40 line of projected letters at 20 ft. and a card with 20/40 letters at 20 in. Base-in or base-out prism was added symmetrically by means of Risley rotary prisms over both eyes until double vision was reported. The amount of prism was then reduced until fusion was regained. These two end points, break and recovery of fusion, were recorded for divergence, convergence, and vertical vergence up and down. (The prism was added over the left eye for vertical vergence testing.) Thus, counting both near and distance results we accumulated 16 values for each patient.

The gross observation of following movements of the eyes monocularly and binocularly (ductions and versions, respectively) served only as a further validation of subjective testing.

Heterophoria measurement was done in a standardized manner using the white multiple Maddox rod over the left eye and the Risley rotary prism over the right eye. Exposed bulbs were used as targets for both the 20 ft. and 13 in. test distance in a darkened eyelane.

The red lens test and near point of convergence were done as outlined in AF Manual 160-1 (see Attachment 5).

Our judgments concerning ocular motility for each man were therefore based upon a fairly comprehensive battery of test results. Some of these tests have a degree of clinical validity in themselves but we did not allow ourselves to be deluded by semantics or empiricism into any overestimation of the value of a given number or measurement. Rather, we regarded these values and charts as a group of clinically useful "peepholes" through which we could get glimpses of the neuromuscular function. It is our impression that the more "peepholes" we use, the greater will be our understanding of the hidden panorama of neurophysiologic mechanisms. From this understanding we can rule out related neurologic disease and attempt to predict future freedom from disease.

In the muscle balance area our predictions are concerned with possibilities of occurrence of asthenopia or diplopia during the extremes and stresses of space flight. Although the occurrence of either or both of these symptoms would probably not incapacitate a space crew member, the resultant annoyance and distraction at crucial times could certainly interfere with his efficiency and destroy confidence in visual observations or visually controlled maneuvers. Therefore, in our opinion, this battery of tests is a vital part of the ophthalmologic space pilot candidate examination.

4. Intraocular Dynamic Function

We include under this heading those measurements and observations which relate to the constantly changing or moving parts of the internal eyeball: pupil reflexes, accommodation, refractive state, and aqueous humor dynamics.

The pupil reflexes are tested in the classical manner, observing direct and consensual reaction to light and constriction in response to accommodation, as well as their shape and equality.

Accommodation was recorded as the near point of accommodation and was performed in compliance with AF Manual 160-1 (Attachment 5).

Because cycloplegia results in a static state of enforced relaxation for accommodation, it allows the accurate objective and subjective determination of refractive state. This information tells us, by inference, a great deal about the dynamics of focusing in the individual's eyes. Our cycloplegic refraction was performed using Mydriacyl*. This rapid-action drug was chosen so that a quick return to normal dynamics could be assured, thus facilitating the compression of the examination schedule.

Tonography was performed as a diagnostic and baseline procedure without any special preparation or water loading. The procedure consists of a 4 minute continuous recording of the intraocular pressure for each eye. The intraocular pressure sensor is an electronic instrument utilizing the same footplate and plunger weights as are employed by the standard Schiotz apparatus. The scale deflections on this electronic model are identical to those of the Schiotz; therefore, the same calibration instruments and tables are used for both. From the 4 minute procedure the "coefficient of outflow facility" (referred to as "C") is obtainable.

The value obtained for C is in terms of aqueous humor outflow in cubic millimeters per minute per millimeter Hg pressure.

---

*Brand of bis-Tropamide, Alcon Laboratories, Fort Worth, Texas

Thus the higher the value of C, the greater the aqueous outflow capability of the eye. A high C value, e.g., 0.20 or higher, indicates little or no probability of development of chronic simple (open angle) glaucoma. Conversely, a low C value, 0.15 or less, points to a much increased risk of glaucoma. When the pressure at the start of tonography is divided by C, the resultant figure (Po/C) has clinical validity. Values of less than 100 are considered to be indicative of normal eyes. A value of 150 or more is almost proof of glaucoma.

To complete the profile of aqueous humor dynamics, we checked the intraocular pressure before and one hour after mydriasis. The absence of any significant change in pressure rules out the occurrence of acute glaucoma from an angle closure mechanism. This was done using applanation tonometry which gives us the most accurate clinical estimation of true intraocular pressure available and, therefore, provided us with excellent baseline tonometric measurements.

The above tests of the "moving parts" of the inner eyeball are of great prognostic value. It can readily be seen that the disclosure of poor accommodation or excessive hyperopia would allow a prediction of asthenopia and blurring within a few months or years. It is our opinion that a minor amount of hyperopia is, however, desirable and that emmetropia (no refractive error) or minor myopia could be definite obstacles to visual efficiency in space operations. These two refractive states would predispose these men to blurred distant vision from "empty field myopia" and "night myopia." Additionally, the slight residual ciliary muscle tonus which frequently follows prolonged near visual effort would result in transient blurring of distant vision for these men when a sudden shift to distant focus is attempted.

To prevent the later necessity for spectacles or glaucoma treatment, we have gathered sufficient data on each candidate so that relatively safe predictions could be made. An important aid to us was the selection of the upper age limits, which eliminated most of the possible problems with both glaucoma and accommodation.

RESULTS AND FINAL RECOMMENDATIONS

In 32 successive candidates we found a few abnormalities but none were indicative of impending clinical disease. Our evaluation on these cases included documentation of the defect, in addition to our carefully weighed opinions concerning the possible effect of the defect upon visual performance in space operations. No abnormality in this group was serious enough to recommend disqualification.

On the basis of the muscle balance group of tests, there were no predictions of future difficulty. Many of the candidates had outstanding fusional amplitudes and little or no heterophoria. Those who had some heterophoria also had more than adequate fusional amplitude with which to compensate. Those who had relatively low fusional amplitude had little or no heterophoria and, therefore, no need for this compensatory capability.

The visual function group of tests, therefore, was the major group which afforded us a basis for grouping or rating the men. Visual function of space crew members should be, in our opinion, as good as is within human capability. It is perfectly true that any intellectually qualified man could perform all visual tasks within a spacecraft in spite of any of a host of visual abnormalities. We also agree that a wide range of visual limitations may be acceptable in certain selected crew members of multi-manned spacecraft. However, for presently projected space operations we are adamant in our opinion that excellent unencumbered vision capability is a must if we are to derive maximum scientific and technologic benefit from each manned venture into space.

Our recommendations concerning examinees reflected this opinion. Thus we included in the group considered as "best qualified" all of the seven men who had binocular acuity of 20/10. All of this group had superior results in most other test areas. Only one of them was not in the "superior" group in night vision testing. In addition, one man was included in this group whose binocular acuity was 20/12.5 but who was outstanding in all other modalities.

Thirteen men were included in the group which were "qualified without reservations." These men all had 20/12.5 binocular acuity and no medically significant defects. Each failed to achieve outstanding results in some area in which an outstanding result could theoretically be of benefit to a space mission.

The men whom we grouped as "qualified with reservations" had 20/12.5 or 20/15 vision but each failed to achieve outstanding results in multiple modalities of theoretical significance to his visual performance in space flight. None of our reservations were serious enough, however, to force us to recommend that his other talents or capabilities be removed from consideration of selection purely on the basis of our eye findings.

Figures 1 through 8 demonstrate the distribution of functional values and visual capabilities for this group. Those readers who are familiar with the "normal" results for this age group will recognize the high percentage of truly outstanding results which these examinees displayed.

SUMMARY

Of the 32 test pilots whom we examined in support of space crew candidacy, none were found to have defects or impairment of visual function significant enough to require a "not qualified" recommendation. Several aeromedically insignificant abnormalities were disclosed, including myelinated nerve fibers in the retina (fig. 9), tiny posttraumatic foveal scar (fig. 10), a small verucca

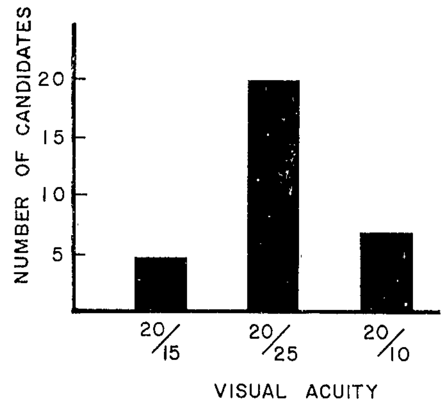


FIGURE 1

Binocular visual acuity at 20 ft.

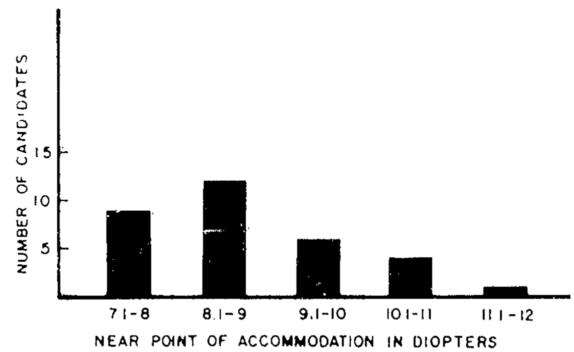


FIGURE 2

Near point of accommodation (better eye)

Rating in accordance with standard Air Force testing instructions, see attachment 5.

FIGURE 3

Night vision

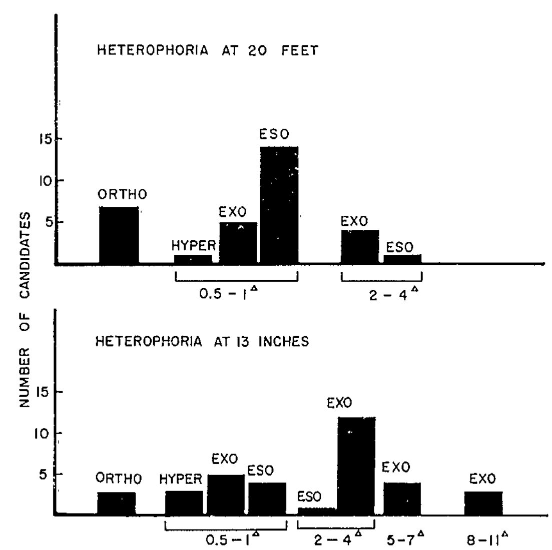


FIGURE 4

Heterophoria measurements

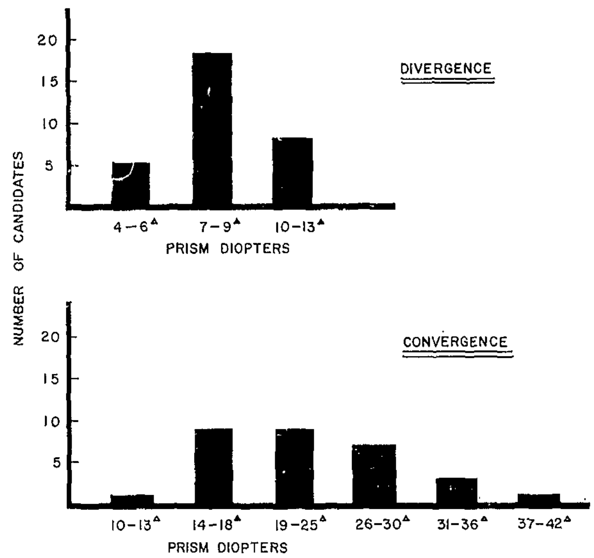


FIGURE 5

Fusional amplitude -- Amount of prism required to break fusion at 20 ft.

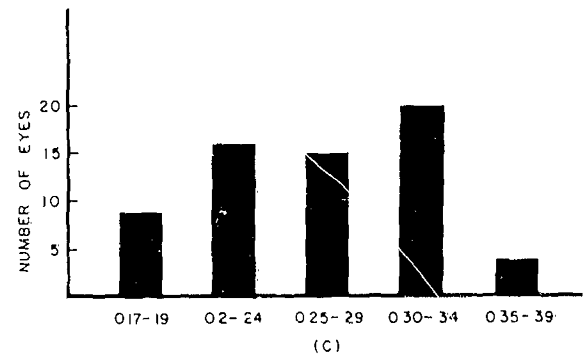


FIGURE 6

Tonography -- Coefficient of outflow facility (C) for 64 eyes

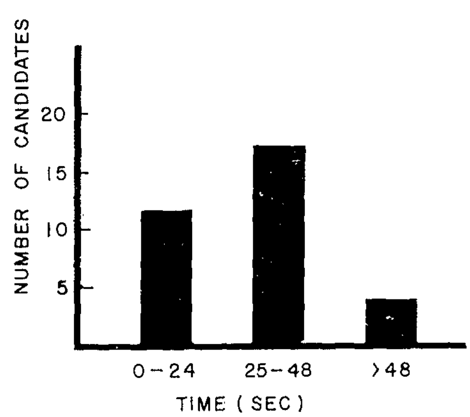


FIGURE 7

Recovery of contrast discrimination -- After photostress of 260,000 lux

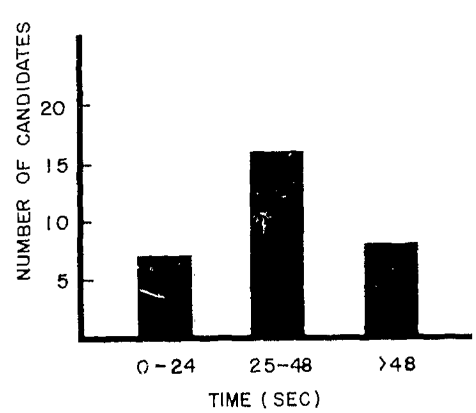


FIGURE 8

Recovery of acuity -- After photostress of 260,000 lux of a lower lid (fig. 11), a mild notching of an upper lid which was a sequel of a repaired lid laceration (fig. 12), and an old healed peripheral chorioretinitis scar. The eye examination did not include all known ophthalmologic procedures but was, in our opinion, sufficiently detailed so that the final selection could be made with confidence that no training or investment would be wasted due to unforeseen but predictable visual incapacity.

Our recommendations on individual candidates were colored by a firm conviction that excellent visual function should be one of the prime requirements for space crewmen in pioneering flights. To send any man out to explore any new environment without an optimum visual capability would be an unjustifiable waste of investment. Likewise, it would be wasteful to allow any significant risk of failure of vision any time after training for such a venture. That this estimation of the importance of vision applies to space flight has been corroborated by the expression of Lt Col John H. Glenn, Jr. (2):

> I believe that the pilot automatically relies much more completely on vision in space than he does in an airplane, where gravity clues are available.

Therefore, a comprehensive eye examination, complete with a critical evaluation of present and future visual function, is a must for candidates for space flight.

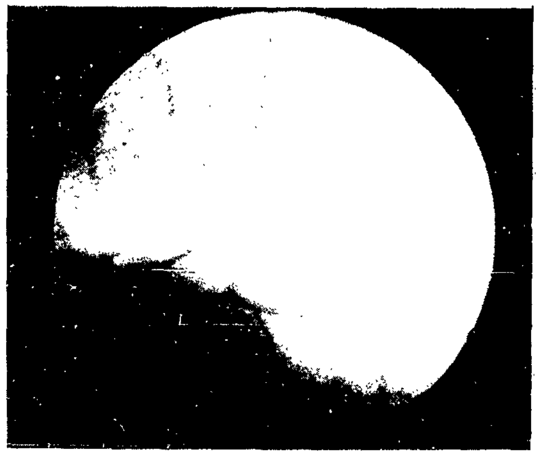


FIGURE 9

Myelinated nerve fibers in retina

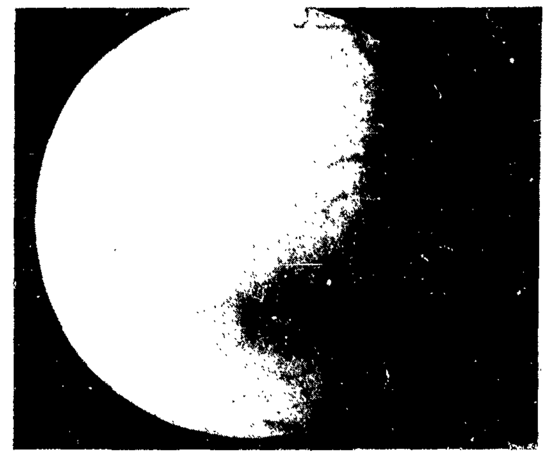


FIGURE 10

Posttraumatic foveal scar

FIGURE 11

Small verucca of lower lid

FIGURE 12

Mild notching of upper lid -- Sequel of repaired lid laceration

ACKNOWLEDGMENTS

Floyd M. Morris, Lt Col, USAF, MSC, contributed to the development of our judgment criteria, as well as to the selection of standard procedures for several of the examination techniques. Norris L. Newton, Captain, USAF, MC, advised and contributed to the development of the form of photostress testing utilized here. Scientific Aide Bernard R. Robinson, A2C, and technicians William H. Brooks, SSgt, and James R. Ables, A3C, performed many of the procedures. The accuracy, reproducibility and facility of the work of these three men provided a solid basis for the physicians' examinations and judgments. Special credit is due William T. Horne, Jr, A2C, and William D. Weir, Jr, MSgt, for their administrative effectiveness in scheduling the work for technicians and physicians. Lawrence E. Lamb, M.D., provided the direction and encouragement without which none of this work would have been possible.

REFERENCES

1. Severin, S. L., N. L. Newton, J. F. Culver. A New Approach to the Study of Flash Blindness - Use of the Zeiss Light Coagulator. Arch. Ophth. 67:578, May 1962.

2. Glenn, John H., Jr., Astronaut. Pilot's Flight Report - Results of the First United States Manned Orbital Space Flight. Manned Spacecraft Center, National Aeronautics and Space Administration, February 20, 1962.

ATTACHMENTS

REQUIREMENTS FOR TIME AND PATIENT LOAD FOR OPHTHALMOLOGIC SPACE CREW EXAMINATION

Block I.	Routine technician's and physician's workups (Undilated) 1 hour; 2 patients at same time
Block II.	Night vision testing (Undilated) 1 hour; 4 patients at same time
Block III.	Mydriatic provocation Fundus photo Cycloplegic refraction Photostress baseline (Dilated) 3 hours; 2 patients at same time
Block IV.	Tonography Gonioscopy ½ hour; one patient at a time

Blocks I, II, and III can be scheduled on the same day.
Blocks I and II can be interchanged as first for subject.
Block II can be done with 4 subjects at a time.
Block III must follow blocks I and II.
Block IV must be performed last and should be 2 days after block III.

EYE EXAMINATION PROCEDURE CHECK LIST

Candidate's name	A	B	C	D	E	F
1. Visual acuity, including binocular acuity	X	X	X	X	X	X
2. External exam	X	X	X	X	X	X
3. Red lens test	X	X	X	X	X	X
4. Near point of convergence	X	X	X	X	X	X
5. Ductions and versions	X	X	X	X	X	X
6. Cover test	X	X	X	X	X	X
7. Fusional amplitudes	X	X	X	X	X	X
8. Accommodation	X	X	X	X	X	X
9. Visual fields	X	X	X	X	X	X
10. Stereopsis	X	X	X	X	X	X
11. Color vision	X	X	X	X	X	X
12. Cycloplegic refraction	X	X	X	X	X	X
13. Slit lamp	X	X	X	X	X	X
14. Ophthalmoscopy	X	X	X	X	X	X
15. Fundus photo	X	X	X	X	X	X
16. Mydriatic provocation	X	X	X	X	X	X
17. Tonography	X	X	X	X	X	X
Po/C	X	X	X	X	X	X
18. Gonioscopy	X	X	X	X	X	X
19. Photostress baseline	X	X	X	X	X	X
20. Night vision	X	X	X	X	X	X

Atch 2

OPHTHALMOLOGIC EXAMINATION

CASE NR	DATE

NAME *(Last, First, MI)*	GRADE	SERIAL NR	AGE	ORGANIZATION	PHONE NR

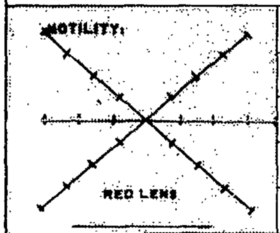
HISTORY OF PRESENT ILLNESS	
	PRIMARY DEPARTMENT
	RATING
	CONVENTIONAL FLYING TIME
	JET FLYING TIME
	TOTAL FLYING TIME

UNAIDED VISUAL ACUITY		DIST	NEAR	PRESENT CORRECTION		SPH	CYL	AXIS	PRISM	ADD	DIST	NEAR
	OD				OD							
	OS				OS							
	OU				DATE PRESCRIBED:							

GROSS EXTERNAL EXAM:

LIDS:	CORNEA:
ADNEXA:	IRIS:
CONJ:	PUPILS:

MOTILITY:



O WHITE
● RED

LENSES	TEST DIST	LATERAL PHORIA	LATERAL FUSIONAL AMPLITUDE BASE-IN	LATERAL FUSIONAL AMPLITUDE BASE-OUT	VERTICAL PHORIA	VERTICAL FUSIONAL AMPLITUDE OD	VERTICAL FUSIONAL AMPLITUDE OS
0.00	20 FEET					S /	S /
						I /	I /
0.00	13 INCHES					S /	S /
						I /	I /

NPC	DUCTIONS:	COVER TEST	DIST:
	VERSIONS:		NEAR:

DEPTH PERCEPTION		ACCOMMODATION	OD: OS:	KERATOMETER
FIELD OF VISION		COLOR VISION		OD:
		TEST USED		OS:

		SPH	CYL	AXIS	PRISM	ADD	V.A. DIST	V.A. NEAR	VERTEX	REMARKS
☐ STATIC RETINOSCOPY ☐ SUBJECTIVE CYCLOPLEGIC DILATED WITH:	OD									
	OS									
MANIFEST	OD									
	OS									
POST CYCLOPLEGIC DATE:	OD									
	OS									
LENSES PRESCRIBED	OD									
	OS									

FRAME SPECIFICATIONS	P.D.	EYE SIZE	BRIDGE	TEMPLE	DECENTER IN-OUT OD / OS	BIFOCAL SEG HT	INSET

SAM HQ FORM FEB 62 0-47 REPLACES AEROSPACE MED CEN (ATC) OFFICE FORM 30, JUN 61, WHICH MAY BE USED. ATCH 3

SLIT LAMP EXAM:

OPHTHALMOSCOPY

INTRAOCULAR TENSION	OD	TECHNIQUE USED:
	OS	WEIGHT:

ECIAL STUDIES *(Gonioscopic, Tonography, etc.)*:

DIAGNOSIS:

RECOMMENDATIONS:

CANDIDATE "A"

COMMENTS AND RECOMMENDATIONS:

A detailed evaluation of Candidate "A's" visual apparatus and function disclosed no ocular contraindications to selection as a space pilot. No evidence was found indicating incipient degenerative or dystrophic diseases. His visual capabilities are, at present, excellent and we can forecast, barring intercurrent disease, efficient and asymptomatic visual function for many years.

Candidate "A" meets the "best qualified" criteria in the following areas: accommodation, stereopsis, visual fields, intra-ocular fluid dynamics, night vision, near and distant heterophoria and near and distant fusional amplitudes. He is in the "qualified" category in his visual acuity and refractive error.

Therefore, from the ophthalmologic standpoint, we highly recommend selection of Candidate "A" for space crew duties.

Please refer to "Special Eye Exam" for the details of this evaluation.

DIAGNOSIS: 3801 Astigmatism, Simple, Hyperopic, O.D.

3802 Hypermetropia, O.S.

Dr. Clark

SPECIAL EYE EXAMINATION:

1. External and internal eye examination: No defects were found on gross or biomicroscopic external and internal eye examination.

2. Visual function examination:

a. Visual acuity:

20'	o.d.	20/20	o.s.	20/12.5	O.U.	20/12.5
20"	o.d.	20/15	o.s.	20/15	O.U.	20/15

b. Accommodation: o.d. 8.0 diopters; o.s. 7.6 diopters.

c. Color vision: Normal color perception.

d. Stereopsis: Normal, passes VTA-ND, A thru F.

e. Visual Fields: Central and peripheral visual fields are normal.

f. Ocular motility:

(1) Ductions and versions are normal.

(2) Normal red lens test.

(3) Heterophoria measurement: 1 prism diopter of esophoria at 20'; 3 prism diopters of exophoria at 13".

(4) Fusional amplitudes:

	Convergence	Divergence	Vertical Vergence, o.s. Up	Vertical Vergence, o.s. Down
20'	15^{Δ}	9^{Δ}	3^{Δ}	2.5^{Δ}
20"	13^{Δ}	14^{Δ}	4.5^{Δ}	3^{Δ}

(5) Cover test reveals no heterotropia.

(6) Near point of convergence: 30 mm.

g. Cycloplegic refraction: o.d. plano +.50 cylinder axis 180, 20/15
o.s. +.50 sphere, 20/15

h. Night vision: "Superior" with night vision tester.

i. Flash-dazzle recovery testing (photostress test at 28,000 foot candles); 0.19 minutes to recovery, contrast discrimination; 0.31 minutes to recovery of acuity.

SPECIAL EYE EXAMINATION (Continued): - page 2

3. Intraocular fluid dynamics:

a. Tonography: o.d. $C = 0.30$, $P_O/C = 45$, $P_O = 13$ mmHg
o.s. $C = 0.26$, $P_O/C = 45$, $P_O = 12$ mmHg

b. Mydriatic provocative test:

Before mydriasis:	o.d., 13 mmHg	o.s., 12 mmHg
After mydriasis:	o.d., 15 mmHg	o.s., 12 mmHg

c. Gonioscopy: Open angles O.U. with visibility to iris base; slight amount of pigment in lower trabeculum O.U.

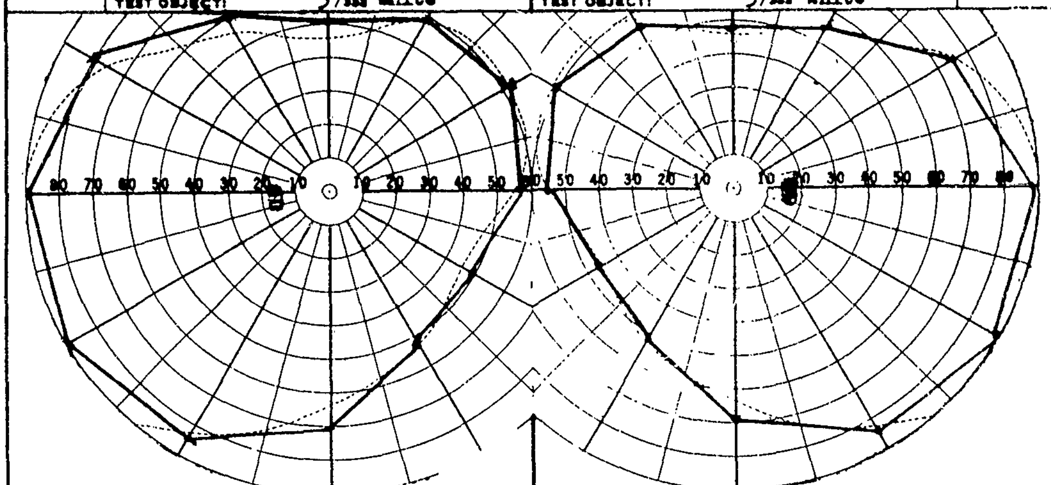
VISUAL FIELD EXAMINATION

NAME (Last, First, MI): CANDIDATE A		GRADE: Captain	AFSN:
VISION	RIGHT: 20/20	EXAMINER: SSgt William H. Brooks	DATE:
	LEFT: 20/12.5		CASE NUMBER:

PERIMETER

LEFT — TEST OBJECT: 3/333 White

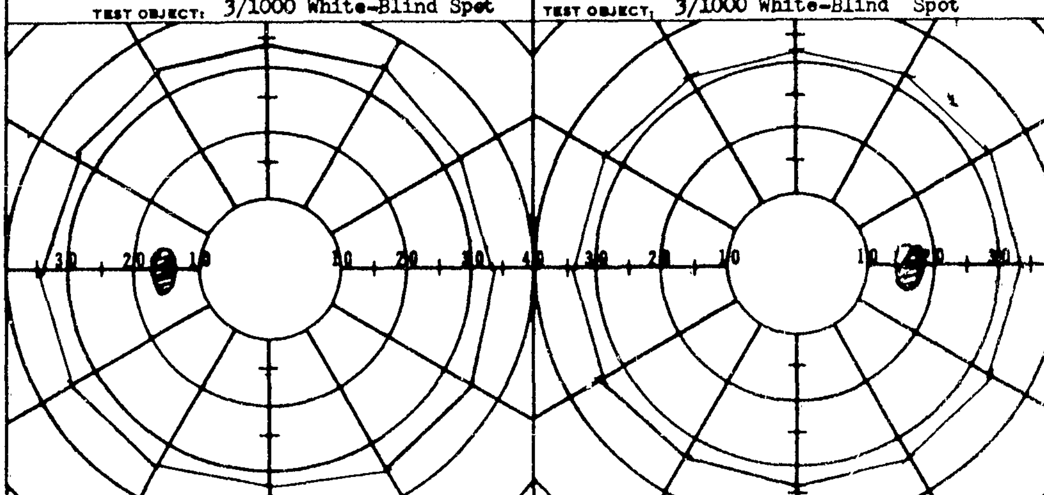
RIGHT — TEST OBJECT: 3/333 White



TANGENT SCREEN

LEFT — TEST OBJECT: 1/1000 White; 3/1000 White-Blind Spot

RIGHT — TEST OBJECT: 1/1000 White; 3/1000 White-Blind Spot



REMARKS

Excellent co-operation

SAM HQ FORM JAN 63 0-22 REPLACES AEROSPACE MED CEN (ATC) OFFICE FORM 44 WHICH MAY BE USED.

PAGE 4

ATCH 4

Extracts From Air Force Manual 160-1, 30 April 1953

RED LENS TEST

A standard lens, test, diplopia, red, Armed Services Catalogue of Medical Materiel, Stock #3-462-800, is placed before one eye. Use of the red lens in the trial case is unsatisfactory because of its small size and dark color. A tangent screen is placed 30 inches from the examinee. A point of light then is moved outward in the six cardinal directions from the center of the screen, right, left, up and to the right, up and to the left, down and to the right and down and to the left. The examinee is instructed to follow the light with his eyes without moving his head and to report either a change in the color of the light (suppression), or a doubling of the light (diplopia). Change in the color of the light should be demonstrated at the beginning of the test by use of the occluder, showing that it may be either red, white, or pink. Verification of the understanding by the examinee is made by moving the light into one of the upper diagonal fields until the brow cuts off the view in one eye. A change in color should then be reported by the examinee. To avoid the danger of routine negative response to testing, a 5-diopter prism placed base up or base down before one eye will produce diplopia which should be reported by the examinee. This prism may be alternated with a plano lens of the same size in order to confuse the examinee. If diplopia or suppression develops when no prism is being used, the point on the screen at which this occurs is noted and recorded. Any diplopia or suppression in the red-lens test which develops within 20 inches of the center of the screen in any of the six cardinal directions is considered a failure.

NEAR POINT OF CONVERGENCE

With the zero mark of the Prince rule placed approximately 15 mm. from the anterior corneal surface, the point of convergence is that point on the rule which marks the greatest convergence of the eyes.

Atch 5

NEAR POINT OF ACCOMMODATION

A Prince rule and an accommodation card will be used. The zero point on the rule should be placed 15 mm. from the cornea. The card will be placed near enough to the eye that the examinee cannot read it and will be slowly moved away. The distance from the eye will be read from the Prince rule in diopters of accommodation and recorded.

NIGHT VISION

The standard night-vision tester is the tester, night-vision, stock #3-821-000.

A. Testing Technique:

1. The tester will be opened only in the dark. If exposed to light it may not be used for 24 hours.
2. A good dark room must be used. No light leaks should be visible after 30 minutes adaptation.
3. The test is a Landolt ring on a radium plaque presented to the examinee at various distances.
4. Unless great care is taken in performing the test, the results may not reflect the examinee's true night-vision efficiency. The operator will explain to the subject the necessity for looking slightly above, below, to the left or right of the target until he finds the direction of fixation at which he can best see it.
5. The Landolt ring is presented first at 5 feet in any of its four settings in random order. The subject must get 4 out of 4 or 8 out of 10 correct. Persons who receive an unsatisfactory score will be carefully re-tested, the best score obtained being taken as the test score. Scoring will be entered on the SF 88 as Superior (Sup.), Satisfactory (Sat.), and Unsatisfactory (Unsat.).
6. Score Classification

10 or more feet	------ Superior
5 to 9 feet	------ Satisfactory
Less than 5 feet	----- Unsatisfactory

Atch 5

COLOR VISION

SCREENING TEST. THE STANDARD SCREENING TEST CONSISTS OF ONE DEMONSTRATION PLATE AND 14 TEST PLATES IN A RING BINDER. THE STANDARD ITEM, VISION TEST SET, COLOR VISION, 15 PLATE, STOCK #3-886-600 WILL BE USED INSTEAD OF THE 17 PLATE PSEUDO-ISOCHROMATIC TEST WHEN IT BECOMES AVAILABLE.

1. LIGHT SOURCE. THE TEST SHALL BE ADMINISTERED UNDER THE EASEL LAMP LISTED IN THE ARMED SERVICES CATALOGUE OF MEDICAL MATERIEL: STOCK #3-456-625, LAMP, COLOR VISION TEST, DAYLIGHT FILTER, WITH EASEL FOR SUPPORTING TEST PLATES.

2. PROCEDURE.

A. THE EASEL LAMP SHOULD BE PLACED ON A TABLE OR SHELF SO THAT THE APPLICANT'S LINE OF SIGHT IS AT RIGHT ANGLES TO THE PLATES AND SO THAT HIS EYES ARE AT A DISTANCE OF APPROXIMATELY 30 INCHES (PLATES JUST OUT OF ARM'S REACH). THE APPLICANT SHOULD NOT FACE AN OPEN WINDOW OR OTHER STRONG LIGHT. NEARBY INCANDESCENT LIGHTS SHOULD BE SHIELDED SO THAT THEY DO NOT ILLUMINATE THE PLATES. NEARBY WINDOW SHADES SHOULD BE DRAWN.

B. THE EXAMINER SHALL INSTRUCT THE APPLICANT TO "PLEASE READ THE NUMBERS". THE EXAMINER SHALL NOT GIVE OTHER INSTRUCTIONS AND SHALL NOT ASK OTHER QUESTIONS. THE APPLICANT IS NOT ALLOWED TO TRACE THE PATTERNS OR TOUCH THE TEST PLATES.

C. THE DEMONSTRATION PLATE MUST BE SHOWN FIRST (A RED "12" ON A BLUE BACKGROUND). ALL OF THE REMAINING 14 PLATES ARE THEN SHOWN. ABOUT 2 SECONDS SHOULD BE ALLOWED FOR RESPONSE TO EACH PLATE. IF THE APPLICANT HESITATES HE SHOULD BE ASKED AGAIN TO "READ THE NUMBER"; IF HE FAILS TO RESPOND, THE EXAMINER TURNS TO THE NEXT PLATE WITHOUT COMMENT.

D. WITH THE EXCEPTION OF THE DEMONSTRATION PLATE WHICH IS ALWAYS FIRST, THE EXAMINER MUST CHANGE THE ORDER WEEKLY AND OFTENER IF THERE IS SUSPICION THAT THE NUMBERS HAVE BEEN LEARNED IN SERIAL ORDER BY APPLICANTS.

3. SCORING: IF 10 OR MORE RESPONSES TO THE 14 TEST PLATES ARE CORRECT, THE EXAMINEE WILL BE CONSIDERED AS HAVING NORMAL COLOR PERCEPTION. THE ENTRY, PASSES--VTS-CV, WILL BE MADE IN ITEM 64, SF 88, IF 5 OR MORE INCORRECT RESPONSES ARE GIVEN, INCLUDING FAILURES TO MAKE RESPONSES, THE EXAMINEE WILL BE CONSIDERED AS HAVING DEFICIENT COLOR PERCEPTION. THE ENTRY, FAILS--VTS-CV, WILL BE MADE IN ITEM 64, SF 88, WITH THE NUMBER OF INCORRECT RESPONSES.

ATCH 5

NEUROLOGICAL EVALUATION

Donald R. Bennett, Capt., USAF, MC

One hour is devoted to each subject for a detailed neurological history and examination. Besides the routine personal and family history the candidates are carefully questioned about episodes of alteration of consciousness, head and back injuries, in-flight hypoxic episodes, neurological dysbarism, headaches, visual disturbances, vertigo, motor or coordination defects, and neck and low back pain. The findings on the neurological examination are entered on a standard form (Attached) along with the results of visual fields, audiograms and caloric tests.

With the exception of a moderately severe cerebral concussion sustained by one subject eight years ago, the neurological histories of the other candidates were essentially negative. A history of syncope, usually during childhood and with adequate cause, was given by four subjects. Complete neurological examinations in this group of space pilot candidates were within normal limits with one exception. One subject had a fine tremor of the hands which had been present since childhood, was non-progressive, and in no way interfered with fine coordination. His mother also manifested the same finding. A diagnosis of familial tremor was made.

Electroencephalograms using monopolar and bipolar techniques are obtained on all space pilot candidates. The total recording time for the resting record is approximately 20 minutes. Additional tracings are obtained during and after five minutes of hyperventilation, photic stimulation, carotid sinus stimulation, carotid artery compression, Weber maneuver, and inhalation for four minutes of a mixture of 93% nitrogen and 7% oxygen.

All EEG tracings utilize 17 electrodes (15 scalp electrodes and 2 ear lobe electrodes). Placement of electrodes on the scalp is determined by the International EEG 10-20 measurement system. Scalp electrodes are .016 inch needles, autoclaved prior to each test. Two ear clip electrodes are used for ear placement. Tracings consist of a resting section of two monopolar runs and two bipolar runs followed by photic stimulation, hyperventilation, carotid artery compression, carotid sinus stimulation, Valsalva maneuver and hypoxic testing utilizing 8% oxygen in nitrogen. The diagrams and descriptions of the various runs are seen in Figs. 1 to 7.

All tracings are made on Grass 8 Channel Model III-D Console electroencephalographs. All channels are utilized for the four resting runs.

Photic stimulation is provided by Grass stimulator model PS-2C. Light flashes are recorded on the first channel of the EEG machine by means of pick-up by a photocell connected to the machine; the remaining seven channels record the EEG tracing.

For hyperventilation seven channels of EEG tracing are made and the 8th channel records respirations utilizing a respirometer. This consists of three major parts: (1) bellows, (2) strain gauge (Statham Labs. Model P6-1D-325) and (3) strain gauge amplifier (Statham Labs Control Unit CB-7). The bellows is strapped to the

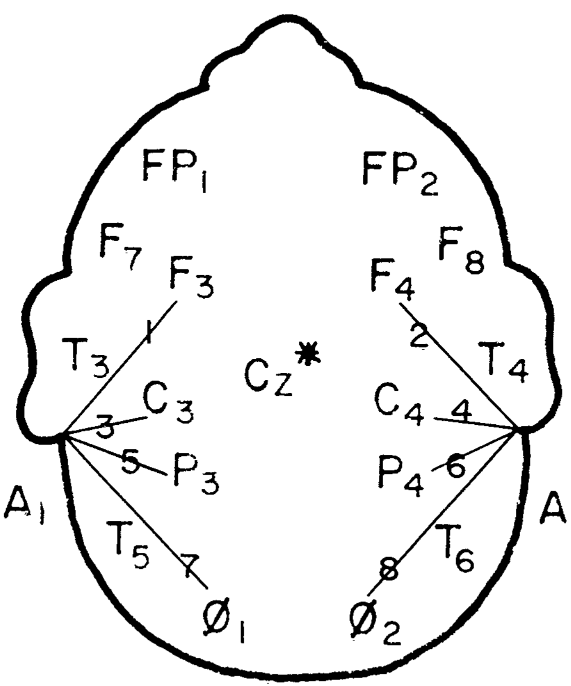


FIGURE 1

Montages for five-minute run with eyes open and closed.

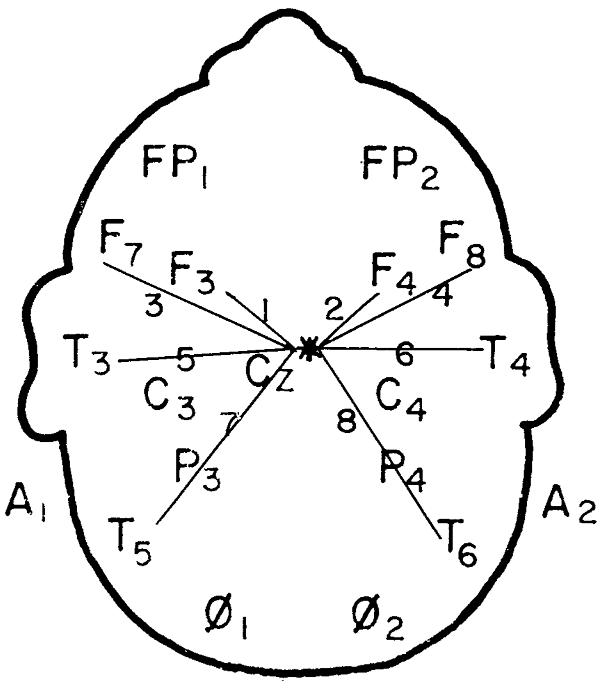


FIGURE 2

Montages for five-minute run with eyes open and closed.

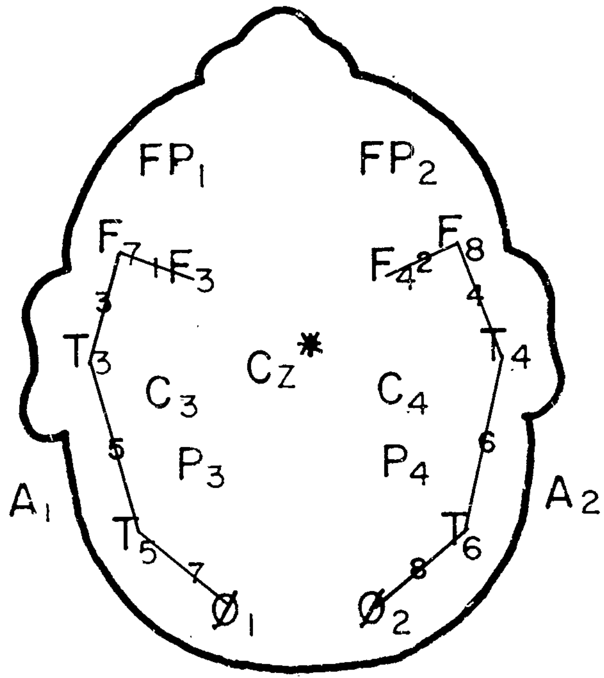


FIGURE 3

Five-minute Bipolar run.

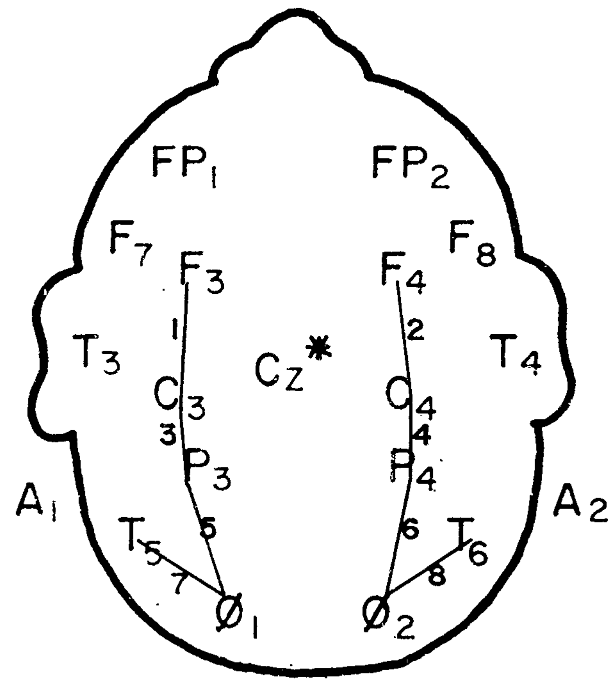


FIGURE 4

Five-minute Bipolar run.

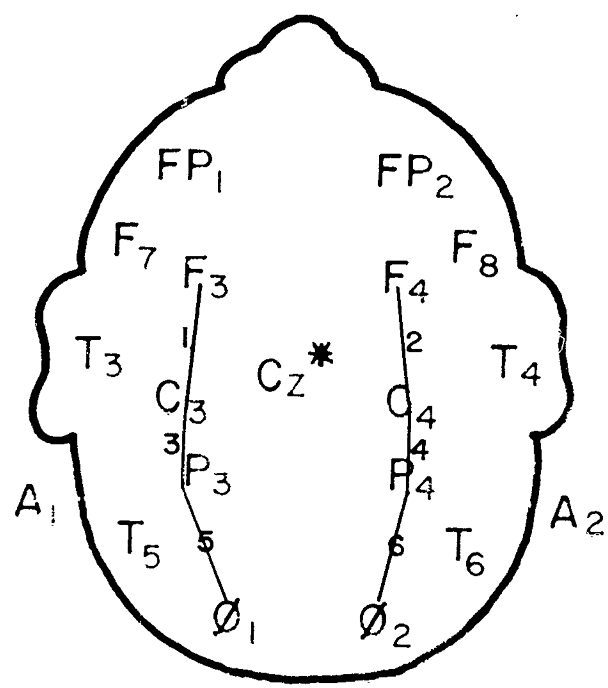


FIGURE 5

Carotid artery compression, carotid sinus stimulation, Valsalva maneuver and Hypoxia Test (same setting for all). Eyes closed in all tests except hypoxia where eyes are open.

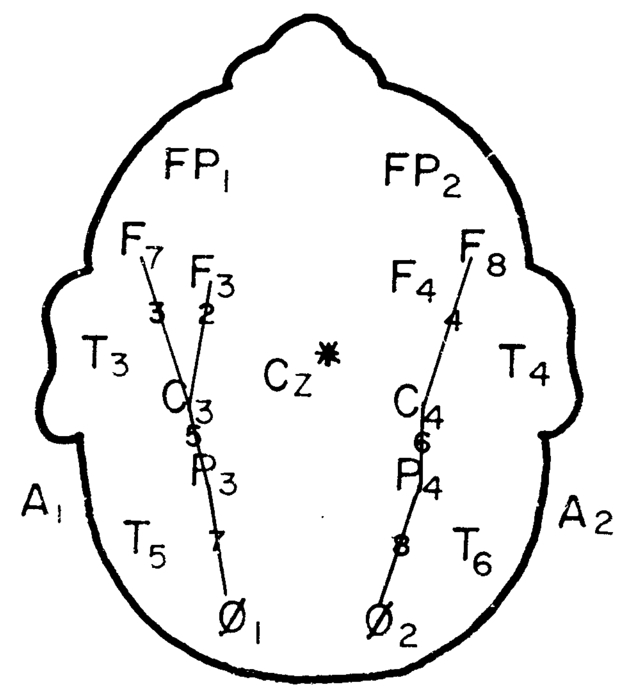


FIGURE 6

Photic stimulation with eyes open 20 seconds during exposure and closed 10 seconds.

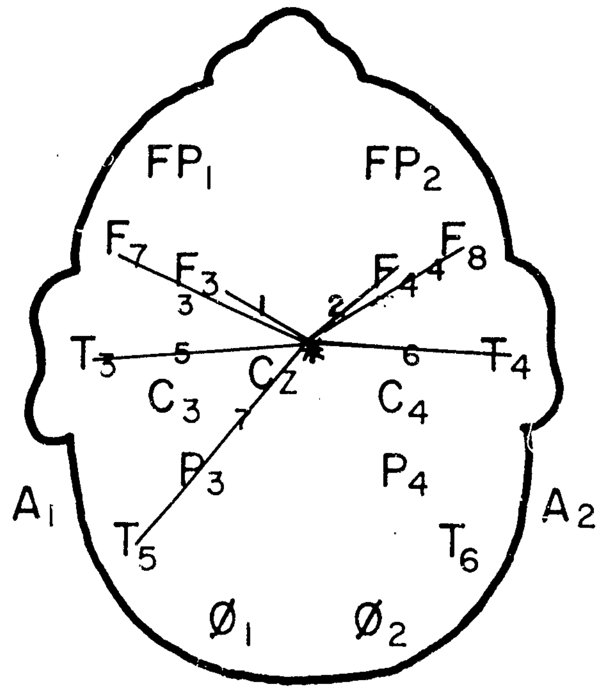


FIGURE 7

Hyperventilation with eyes closed.

patient's chest and changes in the expansion of the chest reflects changes within the bellows which are transmitted directly to the strain gauge through a rubber connecting tube. To prevent artifacts and protect the strain gauge from the expansion of air within the bellows, a vent (20-gauge hyponeedle) is inserted into the connecting tube. The strain gauge is in turn connected to the amplifier which is led into the EEG input box.

For carotid artery compression, carotid sinus stimulation, Valsalva maneuver and the hypoxic test, six channels of EEG tracings are made, the seventh channel records respiration and the eighth channel monitors the electrocardiogram. The electrocardiographic tracings are obtained from two electrodes strapped to opposite sides of the chest by a rubber belt and the electrodes connected to the EEG input box. The chest placement has been found to be the most artifact free arrangement for this particular test procedure.

Subjects are given oral dextrose (50 grams) if they have not eaten prior to the test or if the resting record appears to be slow. The patient's instructions and method of scheduling usually insure against the possibility that the subject will present himself for examination in a fasting state.

In 32 successive space pilot evaluations two subjects had records which were interpreted as mildly and moderately abnormal (Figs. 8 and 9). The personal and family history of these subjects gave no evidence of a convulsive disorder or other CNS disease. An additional candidate

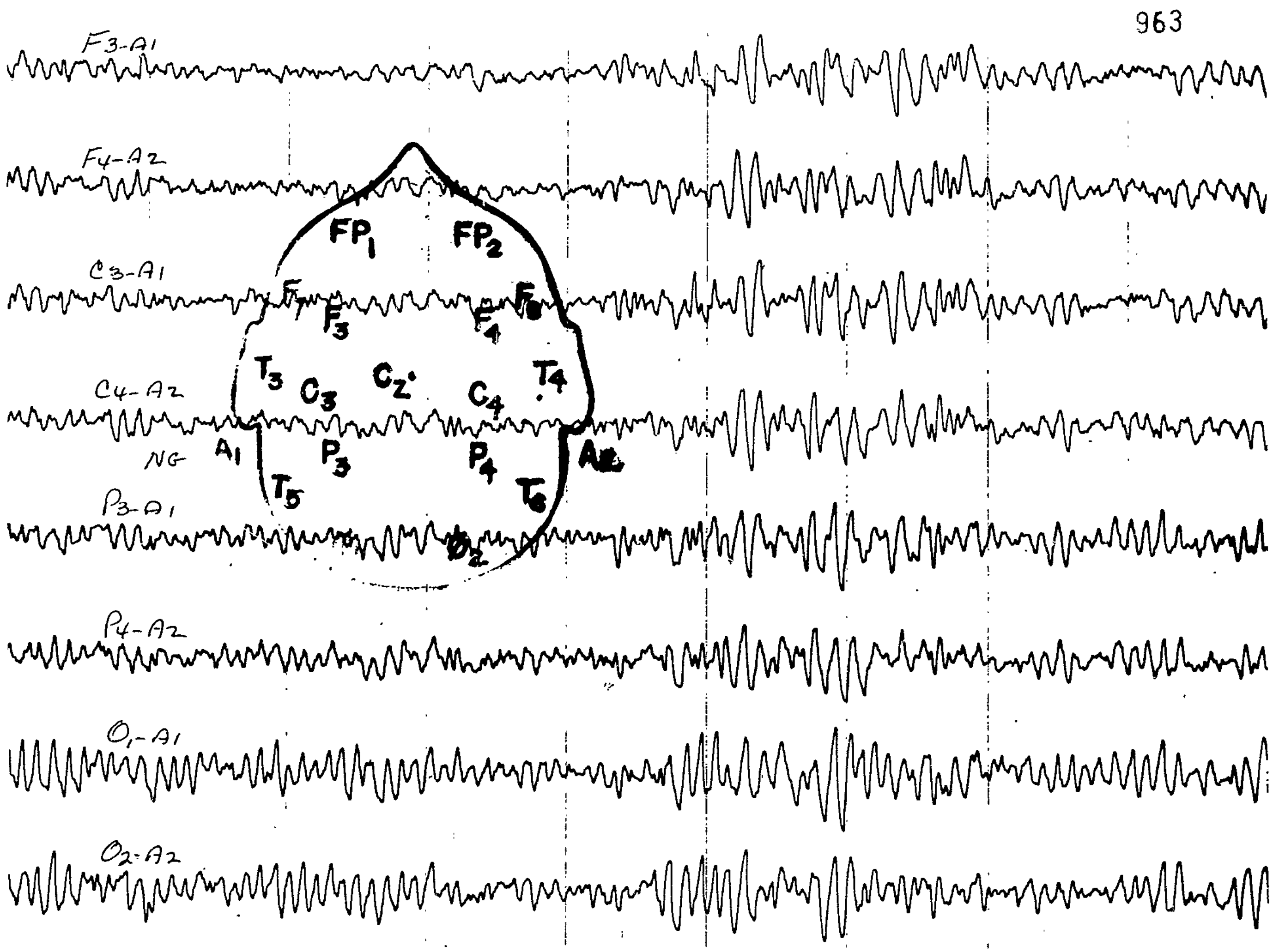


FIGURE 8

Sample of abnormal resting EEG.

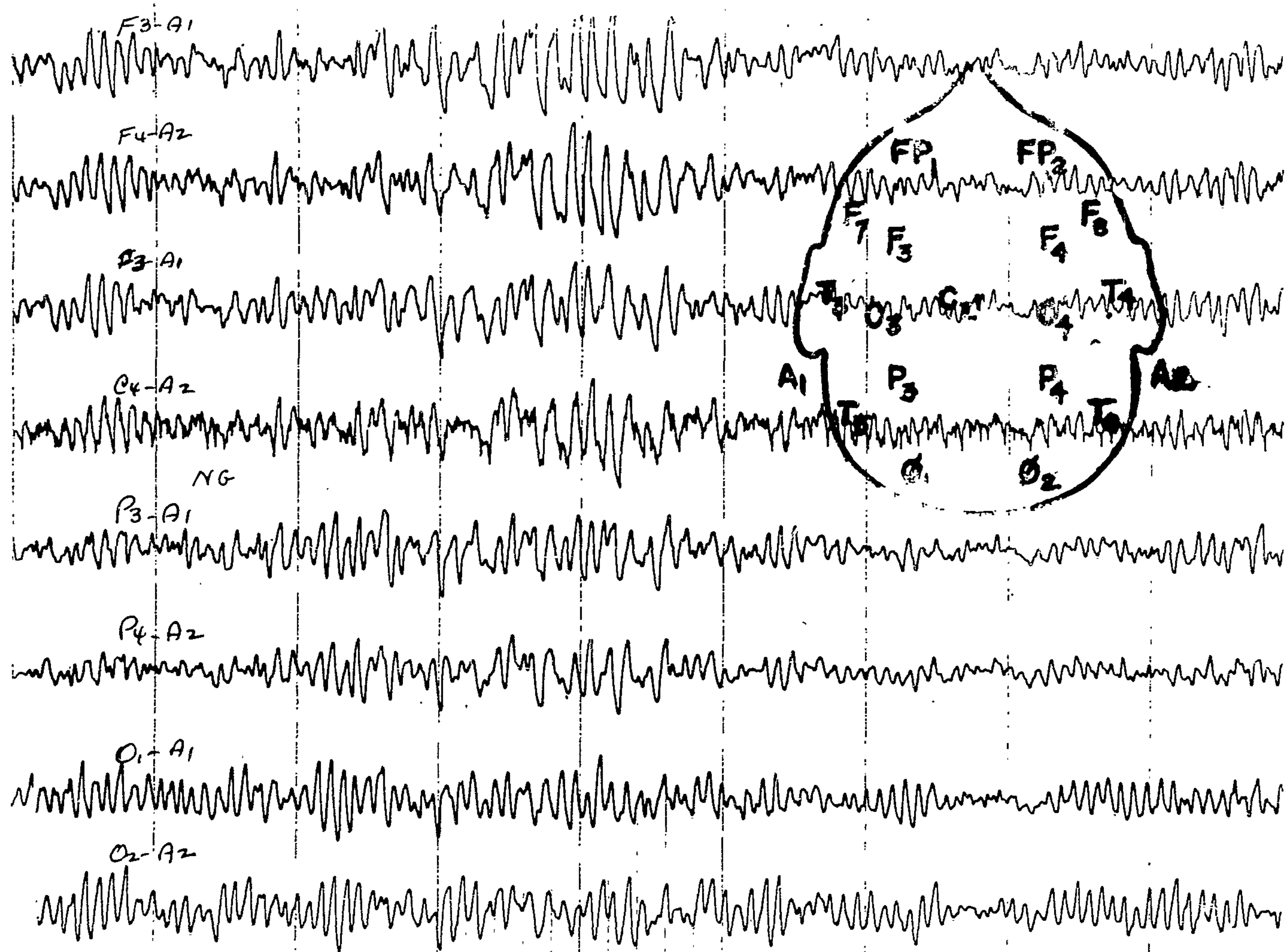


FIGURE 9

Moderately abnormal dysrhythmic EEG.

showed a positive response to left carotid artery compression manifested by slow waves over the left hemisphere (Fig. 10). This was interpreted as being secondary to a decrease in collateral blood flow through an anomalous circle of Willis. The various activating procedures utilized failed to increase the yield of abnormal records or provoke paroxysmal phenomenon. Because of the difference of interpretation that can exist between electroencephalographers the three previously mentioned records were sent to three internationally recognized authorities in electroencephalography for their opinions. Their views are summarized below:

	Record A	Record B	Record C (Carotid Compression)
SAM	Mildly Abnormal	Moderately Abnormal	Abnormal
Consultant 1	Mildly Abnormal	Moderately Abnormal	No Comment
Consultant 2	Within Normal Limits	Within Normal Limits	Abnormal
Consultant 3	Moderately Abnormal	Mildly Abnormal	No Comment

These findings point out the uncertainties in interpreting EEGs in the normal population. It is difficult to make comments on carotid artery compression since there is not much data available concerning the variabilities of this procedure in a relatively normal population.

All skull x-rays were within normal limits. Two cervical spine x-rays showed localized minimal osteophytic encroachment in subjects who were asymptomatic.

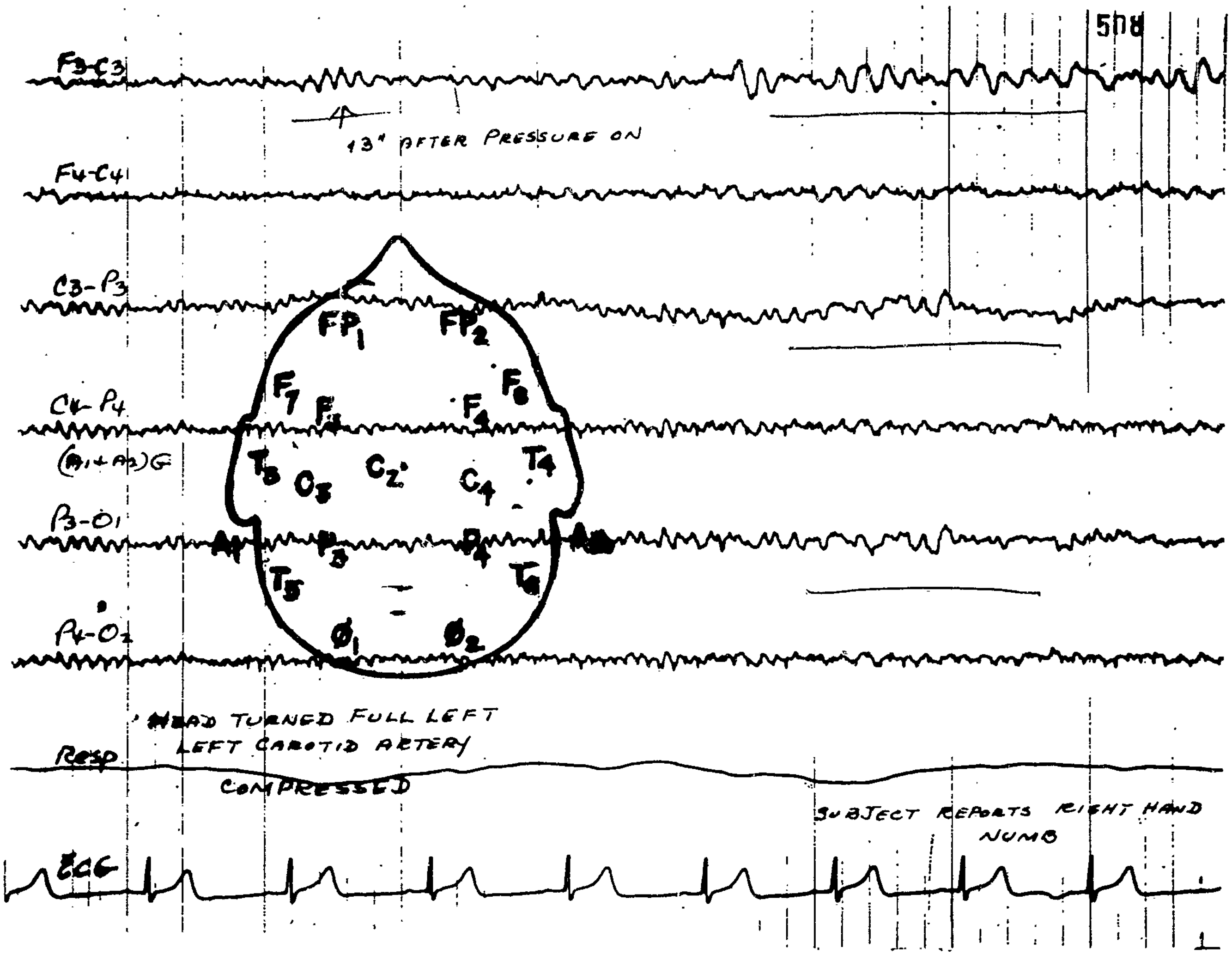


FIGURE 10

Abnormal EEG response to left carotid compression.

SUMMARY

Neurological defects are rarely noted in a highly selected population such as those undergoing space pilot evaluation. The occurrence of two dysrhythmic EEGs coincides approximately with the percentage that this type of record is found in the normal population (10-15%). It is not likely that individuals with records of this type will present any serious problems in interpretation during telemetry of EEGs in space missions. The significance of such dysrhythmic records in normal subjects and its relationship to the susceptibility of the individual to the stresses of flight are not known. This is of concern in aeromedical evaluation since this type of record is found most frequently in individuals with epilepsy. There is need for careful investigation in this area particularly as related to a normal and asymptomatic population.

The positive response to left carotid compression is probably a more significant EEG finding and could indicate serious neurological disease. In view of the negative symptomatology of this individual it was considered most likely secondary to a defect in collateral circulation. Anomalous cerebral vascular circulation in normal individuals is not uncommon.

The occasional requirement for the careful study of an individual with a former head injury within this group of active subjects is not considered unusual. The observance of the minor abnormalities in the cervical spine described above does not present a serious problem and within the limits noted is of little aeromedical importance. The occurrence of the fine tremor described in one subject is exceedingly uncommon for this population but within the limits noted for this individual was thought to have no significant aeromedical implications.

Appreciation is extended to C. Elizabeth Haberer, A/1C Elvin G. Smoyer, and A/1C Edward H. Haskell for their fine technical assistance in performing the EEG studies.

NEUROLOGICAL EXAMINATION			CASE NUMBER
NAME (*Last, First, MI*)	GRADE	AFSN	DATE

SYMBOLS

NT – NOT TESTED   N – NORMAL   AB – ABNORMAL

1. MENTAL STATUS	2. LANGUAGE AND RELATED FUNCTIONS

3. CEREBRAL DOMINANCE

a. HAND	b. FOOT	c. EYE
☐ RIGHT ☐ LEFT	☐ RIGHT ☐ LEFT	☐ RIGHT ☐ LEFT

4. GENERAL APPEARANCE

a. SYMMETRY OF BODY PARTS	b. LOCALIZED PAIN	c. ABNORMAL MOVEMENTS
d. SKIN LESIONS	e. CONG. ANOMALIES	f. BRUIT

5. CRANIAL NERVES

	RIGHT	LEFT		RIGHT	LEFT		RIGHT	LEFT
EOM'S			PAIN			HEARING		
NYSTAGMUS			TEMP			VISION ACUITY		
MASTICATION			TOUCH			PUPIL SIZE		
ARTICULATION			LIGHT REFLEX			PERIPHERAL FIELDS		
SWALLOWING			ACCOMODATION			DISC'S		
FACE AND JAW			CORNEAL REFLEX			MACULA		
TONGUE			GAG REFLEX			VESSELS		
PALATE			SMELL			PTOSIS		
NECK AND SHOULDERS			TASTE			OTHER		

6. EXTREMITIES AND TRUNK

a. MOTOR	UPPER EXTREMITIES		LOWER EXTREMITIES		TRUNK	
	RIGHT	LEFT	RIGHT	LEFT	ANTERIOR	POSTERIOR
STRENGTH						
TONE						

b. REFLEXES	RIGHT	LEFT		RIGHT	LEFT		RIGHT	LEFT
BICEPS			PATELLAR			ABDOMEN		
TRICEPS			ACHILLES			CREMASTERIC		
BR. RAD			PLANTERS					
FINGER FLEX			OTHER					
HOFFMAN								

7. SENSORY

	UPPER EXTREMITIES		LOWER EXTREMITIES		TRUNK	
	RIGHT	LEFT	RIGHT	LEFT	ANTERIOR	POSTERIOR
PAIN						
TOUCH						
TEMPERATURE						
VIBRATION						
POSITION						
DEEP PAIN						
2 POINT						
SENS. EXT.						
FIGURE WRITING						
STEREOGNOSIS						
TACTILE LOC.						

SAM HQ FORM APR 62 0–67   AFPS SA MAY 62, 100

8. COORDINATION

	UPPER EXTREMITIES		LOWER EXTREMITIES		STATION AND GAIT
	RIGHT	LEFT	RIGHT	LEFT	
F–N					
H–S					
POSTURE					
REBOUND					
RAM					
FINE MOVEMENTS					

9. ADDITIONAL FINDINGS AND SUMMARY OF DEFECTS

PSYCHIATRIC AND PSYCHOLOGICAL EVALUATION

DON E. FLINN, LT. COL., USAF, MC, FS

BRYCE O. HARTMAN, PH.D.

DOUGLAS H. POWELL, Ed.D., 1ST LT., USAF, MSC

RICHARD E. McKENZIE, Ph.D., MAJOR, USAF, MSC

INTRODUCTION

Since the inception of manned space flight programs, there has been interest in potential psychological problems. Initially, interest was focused upon proficiency and reliability during space flight. Isolation and confinement, and the behavioral effects of weightlessness are two such problem areas. In addition, there has been interest in the space pilots' psychiatric and psychological adaptability for space flight. Sells and Berry (6) were among the first to point out the significance of psychological selection for manned space programs. In the program to be described, the space pilots' adaptability is studied within the framework of a more comprehensive medical evaluation rather than as a separate evaluation.

The purpose of this portion of the evaluation is to assess the candidates in terms of those psychological characteristics which are considered most important for adaptability to space flight. This requires that the examiners understand the job requirements for space missions, that they formulate the psychological characteristics which would seemingly contribute most to effective job performance, and that the candidates be assessed for those characteristics.

It is assumed that the job requirements will be very similar to those of test pilots. The candidate's actual flying and test ability as a pilot is considered of great importance, but not a primary focus for this assessment. It is assumed that the initial screening criteria for space pilots would insure that all those undergoing aeromedical evaluation would have a high level of technical ability as a pilot. Hence, the psychiatric and psychological evaluation was focused on the emotional and personality factors considered important in overall job performance. Previous experience in evaluating candidates for a variety of high-priority, high-hazard Air Force assignments contributed considerably to the methods.

It is impossible to develop an absolute list of personal and psychological factors which are most desirable for space pilots. Such highly specialized groups of individuals as experimental test pilots may vary widely in general personality traits, yet share a common excellence in handling the unconventional problems that occur in experimental flying. However, within the framework of present knowledge, the personality areas that are deemed most important can be categorized as follows:

1. General emotional stability: absence of neurotic or psychotic symptoms, and freedom from problems in the social, marital or financial spheres; ability to tolerate stress and frustration without significant emotional symptomatology

or impaired performance.

2. High motivation and energy level: demonstrated ability to pursue realistic and mature goals with determination and initiative; capacity to think in a creative and flexible manner when unforeseen events occur.

3. Adequate self-concept: strong confidence in self and capacity to give opinions and make independent decisions without overconcern; at the same time, ability to depend on judgment of others when the mission warrants.

4. Interpersonal relationships: ability to form satisfactory and productive relationships with supervisors, peers, and subordinates, but not be overly dependent on people for satisfaction; capacity to function as a team member in any role.

To uncover data which would bear productively on these general categories of the evaluation framework, an extensive psychiatric and psychological evaluation of each candidate is made. Each applicant is assessed by a variety of interviews and test procedures given by several examiners. The assessment program consists of:

1. Psychiatric interviews
2. Clinical psychological testing
3. Performance stress testing

These techniques will be explained in detail in the sections which follow.

PROCEDURES

Psychiatric Evaluation: Each evaluee is interviewed by two psychiatrists. The first interview is two hours in duration; the second of one hour's duration, is the final procedure in the psychiatric and psychological assessment. A psychiatrist also observes the subject's performance during the performance test described below. During the final interview, any areas which warrant further attention are explored. The psychiatrist has available to him for this purpose any data from the earlier psychological or psychiatric information which are pertinent. Although the interviews were nondirective to some extent in that no formal list of questions is used, each examiner attempts to assess certain areas which have been agreed upon. These are as follows:

1. Review of flying career and experiences:

original and current motivation; adaptability during training; major goals and reasons for changes; evidence of outstanding or ineffective performance; reaction to frustrating experiences; quality of relationships with co-workers and supervisors; reaction to competition and failure; adaptability to combat, test flying and other stressful experiences;

2. Motivation for space flight:

expectations: realistic vs unrealistic; pros and cons considered; quality and quantity of motivation; current job satisfactions; alternate goals;

3. Marital history:

marital adjustment; wife's attitude toward job; current situational problems; family adaptability to past transfers and separations; causes of marital discord, and response to them;

4. Developmental history:

early relationship with parents and siblings; causes of intrafamily tensions and applicants response or participation; early educational history, academic achievements; social and sexual adjustment during and after adolescence; avocational interests

5. Psychiatric history:

hospitalizations or consultations; symptom review; use of alcohol;

6. Current situation:

family relationships; social and recreational interests; interpersonal relationships.

One aim of the interviews is to screen out any individuals with personal or interpersonal adjustment difficulties which interfere significantly with performance. Since this is a highly selected group in terms of demonstrated effectiveness, it is considered unlikely that psychopathology of this degree would be encountered. However, early detection of any such individuals is most important. Beyond this, an attempt is made to assess the intellectual and personality characteristics which would affect the applicant's over-all adaptability and effectiveness in a space program.

Each psychiatrist relies heavily upon his clinical judgment, and experience in dealing with flyers. He tries to subjectively evaluate the personality characteristics of each candidate in terms of the job requirements which had been formulated. In general, considerable weight was given to the candidate's overt behavioral and personality characteristics, with relatively less weight being given to emotional conflicts which seemed unrelated to job performance and effectiveness. For example, an individual who tends to be somewhat anxious and unsure of himself in new situations, based upon some conflict centering around self-esteem, would not necessarily be rated down if he controls these feelings well, if his initiative is not inhibited by them, and if he has amply demonstrated effective performance despite the anxiety. Similarly, a certain degree of aloofness or distance in interpersonal behavior is not considered detrimental if it does not impair cooperative job performance, and if it does not provoke significant adjustment problems in the individual's intimate interpersonal relationships. Our definition of "normal" and "adaptable" tends to be operationally oriented; emotional conflicts which the individual has come to terms with, without undue anxiety, personality constriction, or the use of defense mechanisms which interfere with effective, group oriented behavior are not given undue weight. Emotional conflicts which are only partially resolved, and are considered to represent areas of "emotional vulnerability" even though overt behavior is well-controlled, might cause an applicant to be recommended with some reservation. This could include individuals with poorly controlled impulsivity and hostility, or inadequate defenses manifested by rigidity, constriction, or undue anxiety. In addition, nonpersonality factors might influence a rating; for example, the influence that intrafamily problems of any nature might be expected to have on participation in a program is considered, even though the problems might be in no way related to the applicant's own personality or emotional stability.

An attempt is also made to identify positive attributes which indicate a capacity for unusually effective behavior and performance, even in comparison with this highly select group. Certain characteristics are considered highly desirable. One of the most important of these is the ability to perform effectively despite physical and psychological stress. In addition, high motivation and persistence are considered important for a program which will be highly technical and intellectually demanding. High energy level, aggressive pursuit of job oriented goals, and an enthusiastic approach to work in general is also regarded as highly desirable, as is the ability to work smoothly and cooperatively with others. During the psychiatric interviews, evidence of these characteristics is sought in the individual's posteducational and occupational history.

In addition, each psychiatrist objectively rates a number of personality variables. These variables have been arrived at in the course of aeromedical evaluations. An attempt has been made to define variables which are relevant to the type of information obtained and the formulations made during a psychiatric interview. They have been refined until they are relatively independent of each other. Definitions of each of the variables were developed, and used as a guide by all of the psychiatrists. Among normal, symptom-free and well-adapted individuals one sees a variety of drives, emotional conflicts, and defensive maneuvers in use; while these areas are commented upon in the usual psychiatric personality assessment, objective ratings of these make it possible to compare subjects with each other, as well as to compare individual characteristics with later adaptability to aerospace programs. It is recognized that a rating scale of this type fails to adequately reflect some of the subtle and meaningful information observed during an interview, and in particular does not reflect the important interrelationship between the various personality characteristics which it describes. Nevertheless, it is considered desirable to make some systematic descriptive statements about the candidates in this manner.

A six-point rating is used (Fig. 1). Each scale is positioned on the form so that the hypothetical optimal quantity of each characteristic will yield a straight line; i.e., the most adaptive individual would have ratings which form a straight line on the rating form. The variables, which were arrived at through repeated use and refinement, are grouped in accordance with the following conceptual scheme: The first group consists of certain conceptualized drives or motivations which are reflected in interpersonal behavior. Some of these are similar to Murray's "needs." Here, the overt or manifest degree of each of these traits is rated, with no attempt to indicate the amount which might be considered "repressed." The second group of variables reflects the individual's "self-system" and feelings about himself. The third group includes his accustomed defense mechanisms;

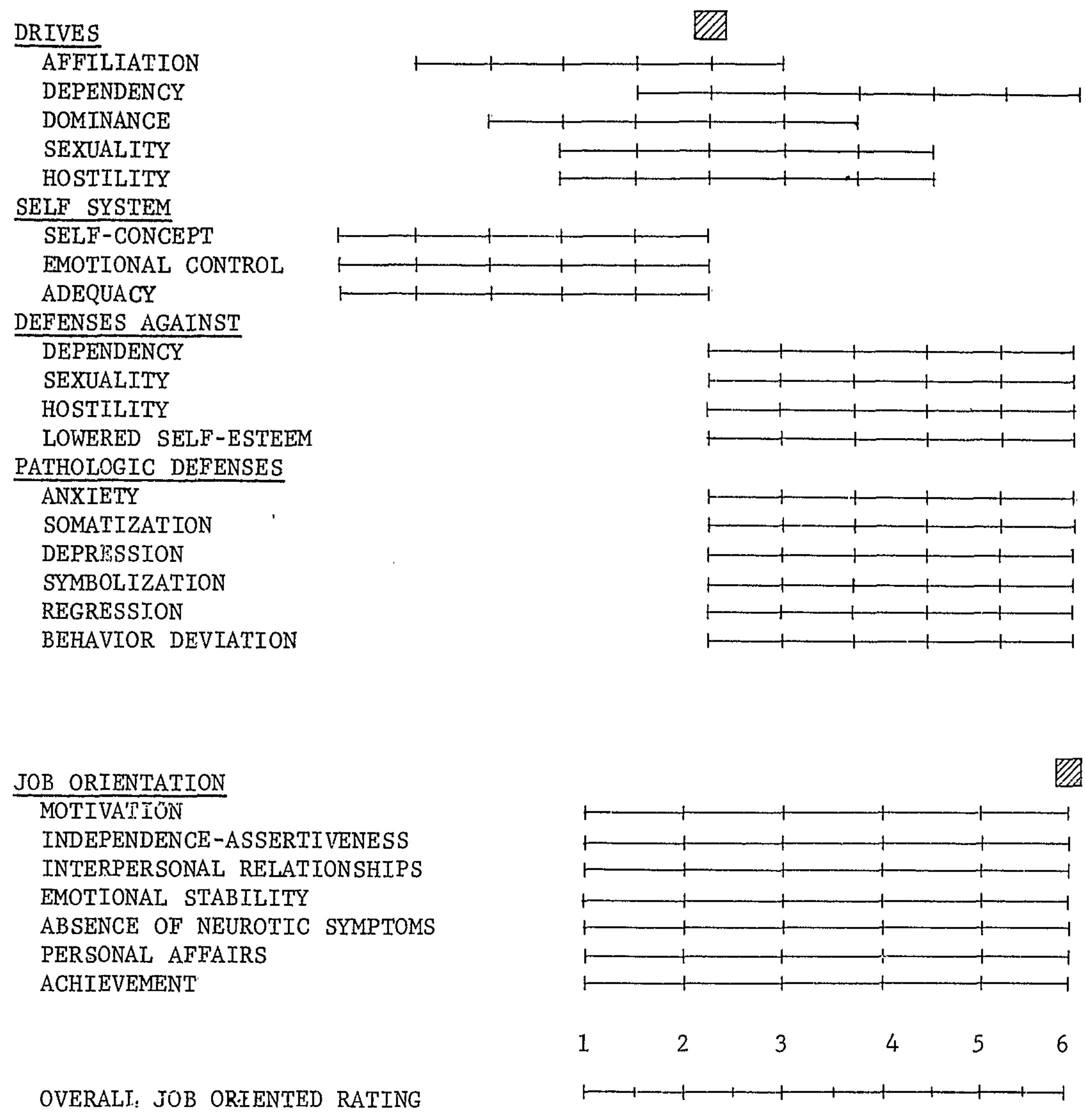


FIGURE 1

SPACE PILOT EVALUATION. Personality variables and job oriented items rated during the psychiatric evaluation. The personality scales are positioned on the form so that the hypothetical optimal quality of each characteristic will yield a straight line.

rather than attempting to rate all of the numerous defense mechanisms which may be seen, these variables consist of the most common conflict areas which the individual may need to defend himself against by whatever means. It is here that unconscious factors which affect behavior are reflected in the ratings. And finally, pathologic defenses are rated. These consist of generic defense mechanisms, any one of which may be common to a number of psychopathologic diagnostic categories. Each of these variables has been defined, and has been discussed by the psychiatrists involved in the evaluations. These variables are as follows:

1. Needs:

   affiliation; dependency; dominance; sexuality; hostility;

2. Ego system:

   self-concept; emotional control; adequacy;

3. Ego defenses against:

   dependency; sexuality; hostility; lowered self-esteem;

4. Pathologic defenses:

   anxiety; somatization; depression; symbolization (substitution, displacement); regression; and behavior deviations.

A job oriented rating is made of factors which are considered to be particularly important to the specific characteristics of the job. The items rated are as follows: Motivation, Independence-assertiveness, Interpersonal relationships, Emotional stability, Absence of neurotic symptoms, Personal affairs, and Past achievement (Fig. 1). The final evaluation is based upon clinical information obtained during the interview. No attempt is made to formally weigh all of the other ratings, and use them to compute an over-all rating.

These ratings are of some value in helping the examiners to consider the applicant's major personality attributes in a systematic manner; however, their primary usefulness will be in a later comparison of the individual's performance in a space program with an objective description of personality variables. For this reason, no report is being made at this time of the results of these ratings.

Psychological Testing: Approximately eight hours are required for each evaluation. Six and one-half hours are devoted to psychological testing and the remaining time is used for the performance-stress tasks. A battery of ten psychological tests is used.

1. Wechsler Adult Intelligence Scale is an individually administered measure of intelligence, consisting of eleven separate Verbal and Performance sub-tests; a well-standardized instrument commonly used in clinical evaluation of flying personnel in this laboratory. It provides measurement of a broad spectrum of behavior and adequate though not outstanding discrimination at the upper ranges of intelligence.

2. Miller Analogies Test is a timed group test correlating highly with general intelligence and verbal achievement measures. This test consists of 100 multiple choice paired analogies. It is a well-standardized test with comparable norms available, permitting differentiation for verbal abilities at a very high level.

3. <u>Doppelt Mathematical Reasoning Test</u> is a timed group test consisting of 50 multiple choice problems requiring the identification of complex mathematical principles. It is another well-standardized instrument whose published norms enable high level differentiation.

4. <u>Minnesota Engineering Analogies Test</u> is a 50-item high level objective measure of specific engineering knowledge, combining features of an abstract reasoning test with those of engineering achievement. Excellent standardization allows for good separation among candidates at high levels.

5. <u>Rorschach Inkblot Test</u> is a projective test consisting of ten ambiguous inkblots of various shades and colors to which the subject is asked to respond in an unstructured manner. It is the oldest and perhaps most stable of all the projective multi-dimensional tests. Though research findings about this measure are equivocal, its multifaceted contribution to the assessment profile plus the considerable experience of the evaluation team using this instrument with comparable populations resulted in its inclusion.

6. <u>Thematic Apperception Test</u> is a projective test consisting of a series of pictures depicting ambiguous, usually interpersonal situations about which the subject is instructed to make up a story. This laboratory's battery of TAT pictures used 11 of the 30 possible ones (in order, 1, 3BM, 4, 6BM, 7BM, 8BM, 12M, 13MF, 18GH, 18BM, 16). Multi-dimensional analysis is possible. This is the second most widely used personality test and one for which a great deal of

comparable data is available.

7. Draw-A-Person Test is a brief projective test. The subject is asked to draw a figure of a person and then one of the opposite sex. From these drawings inferences about self-concept, ego boundaries, and possible conflict areas can be made. While the data from this test are not always contributory to an assessment in each case, the drawings frequently enable significant personality differentiations to be made when other evidence is equivocal.

8. Bender Visual Motor Gestalt Test consists of nine designs, reproduced one at a time by the subject on a plain 8 x 11 piece of paper. Later in the testing the candidate is asked to reproduce the forms from memory. This test has been demonstrated to be useful both as a neurological screening device and as a projective technique.

9. Gordon Personal Profile Test is a self-administered personality inventory consisting of 18 tetrads of descriptive phrases. It provides a quick assessment of five traits - Ascendancy, Responsibility, Emotional Stability, Socialability, and over-all Self-evaluation. The main virtues of this test are the small amount of time required for its administration and the availability of comparable Air Force norms.

10. Edwards Personal Preference Schedule is a 247 item personality inventory in which the candidate must choose between two descriptive phrases as being more like himself. The test is then scored for 15 manifest needs (i.e., achievement, deference, etc.)

similar to those described by Murray, and a consistency score which is a measure of profile stability. This test has the virtue of focusing on the relative strengths of normal personality variables rather than concentrating on pathology. Comparable Air Force norms are available.

The means, standard deviation, and quartiles for 79 of the more important test variables for one special group are shown in table I.

These candidates were of rather high intellectual quality and their aptitude test scores are also above the average. The mean IQ for these candidates was 132.1 which is in Wechsler's highest category. This is about nine points higher than the average Full Scale WAIS IQ of 122.7 based on a recent study in this laboratory of 200 flying personnel. While there is no difference in average Verbal and Performance IQ, the variance in the Performance IQs is significantly greater than among the Verbal scores ($p < .01$). The WAIS scores fall in a relatively narrow range, particularly the Full Scale and Verbal IQs. The candidates are at the upper end of the score distribution for this test, the average Full Scale IQ being nearly two standard deviations from the mean for the population at large. The range of scores among the Performance tests was much greater, even though the mean of all IQs was nearly the same as the Verbal and Full Scale

TABLE I

DESCRIPTIVE STATISTICS FOR 79 VARIABLES FOR 32 SPACE PILOTS' EVALUATION

VARIABLE	MEAN	S.D.	HIGHEST	Q_3	Q_2	Q_1	LOWEST
1. Clin. Psych. Rating	3.63	0.90	5.3	4.25	3.80	2.90	2.0
2. Tracking Error	1.93	1.31	5.6	2.35	1.65	1.00	0.3
3. Tracking Rating	3.73	1.10	6.0	4.40	3.80	3.00	1.2
4. Audit Correct %	27.2	14.3	66.	41.0	28.5	31.5	7.0
5. Audit Error %	8.7	5.0	24.	10.5	6.5	5.5	4.0
6. Audit Confusion %	22.9	13.9	60.	32.0	19.5	13.0	5.0
7. CBS Slow Speed % Eff.	77.3	10.1	95.	84.0	79.0	71.0	54.
8. CBS Slow Speed % Prof.	13.1	6.8	31.	14.5	11.0	8.5	6.
9. CBS Medium Speed % Eff.	61.4	12.4	80.	68.5	64.0	57.0	19.
10. CBS Medium Speed % Prof.	17.5	11.7	68.	19.0	15.5	12.0	4.
11. CBS High Speed % Eff.	60.0	12.5	82.	70.0	58.5	53.0	32.
12. CBS High Speed % Prof.	28.2	9.7	53.	33.0	27.5	22.0	12.
13. CBS Overall % Eff.	-17.1	15.2	+15.	-71.0	-19.5	-27.5	-47.
14. CBS Overall % Prof.	15.1	7.9	+36.	20.0	15.5	9.5	-3.
15. Overall Perf. Stress Rating	3.38	1.11	5.0	4.30	3.30	2.55	1.0
16. Overall NP Rating	3.80	0.75	5.2	4.40	3.85	3.10	2.6
17. Overall NP Ranking	16.5	9.4	32.	24.0	16.0	8.5	1.
18. Psychiatrist 1 Rating	4.32	1.12	6.0	5.10	4.25	3.90	2.0
19. Psychiatrist 2 Rating	3.93	1.05	6.0	4.50	4.00	3.50	1.5
20. Edwards Deference	50.3	7.5	63.	56.0	51.0	45.5	29.
21. Edwards Order	49.2	11.4	72.	53.5	50.0	43.5	18.
22. Edwards Exhibition	50.8	9.5	70.	56.5	52.0	43.0	27.
23. Edwards Autonomy	51.7	9.9	72.	57.5	50.5	44.0	33.
24. Edwards Affiliation	51.7	8.8	68.	58.0	51.5	48.0	29.
25. Edwards Intraception	49.7	10.0	78.	55.0	49.0	41.0	35.
26. Edwards Succorance	46.4	9.7	76.	51.5	44.5	39.0	34.
27. Edwards Dominance	51.9	9.3	66.	60.0	54.0	43.5	31.
28. Edwards Abasement	48.7	6.8	59.	55.0	48.0	43.5	36.
29. Edwards Nurturance	47.8	7.4	65.	54.0	48.0	41.0	35.
30. Edwards Change	50.6	8.2	64.	56.0	51.5	55.5	23.
31. Edwards Endurance	51.2	10.5	70.	59.0	50.5	44.5	28.
32. Edwards Heterosexuality	44.4	10.7	64.	53.0	43.0	38.0	24.
33. Edwards Aggression	51.9	7.8	70.	57.0	50.0	47.0	34.
34. Edwards Consistancy	52.5	9.3	67.	61.0	55.0	42.0	32.
35. Gordon Ascendency	51.6	8.7	69.	58.0	51.0	46.0	31.
36. Gordon Responsibility	53.2	9.0	66.	59.5	5.0	50.5	41.
37. Gordon Emot. Stability	53.6	9.7	68.	60.0	56.5	47.0	24.
38. Gordon Sociability	46.2	7.2	67.	48.0	45.0	43.5	31.
39. Gordon Total	52.6	8.8	58.	57.0	57.0	51.0	14.
40. Ror. W %	40.3	22.0	100.	48.5	36.0	23.5	11.
41. Ror. D %	47.7	21.0	87.	60.0	50.5	36.5	0.
42. Ror. d %	4.4	5.9	23.	7.5	3.0	.0	0.

(Cont'd)

TABLE I

DESCRIPTIVE STATISTICS FOR 79 VARIABLES FOR 32 SPACE PILOTS' EVALUATION

VARIABLE	MEAN	S.D.	HIGHEST	Q_3	Q_2	Q_1	LOWEST
43. Ror. DdS %	7.7	8.0	31.	11.0	6.0	.0	0.
44. Ror. # Popular	7.2	2.3	13.	9.0	7.0	5.5	3.0
45. Ror. # Content	9.5	2.2	14.	11.0	9.5	8.0	6.0
46. Ror. # W	10.0	4.6	24.	12.5	9.0	7.0	2.0
47. Ror. # D	14.8	9.0	35.	20.5	14.5	9.5	0.
48. Ror. # d	1.8	3.0	13.	2.0	1.0	.0	0.
49. Ror. # DdS	3.2	5.0	26.	3.5	1.5	.0	0.
50. Ror. # M	3.3	2.3	8.	4.5	3.0	1.5	0.
51. Ror. # FM	4.3	2.5	10.	6.0	4.0	2.0	0.
52. Ror. # m	1.9	1.8	7.	3.0	1.0	1.0	0.
53. Ror. # Sex Resp.	.4	0.8	3.	.5	.0	.0	0.
54. Ror. # At. Resp.	1.3	1.4	5.	2.0	1.0	.0	0.
55. Ror. % Resp to Achrom Cards	44.7	7.8	65.	60.0	44.0	39.0	32.
56. Ror. % Resp to Chrom Cards	55.3	7.8	68.	61.0	56.0	50.0	35.
57. Ror. C	30.8	20.2	80.	42.5	30.0	15.0	0.
58. Edwards Achievement	61.1	6.5	70.	67.0	62.0	58.0	38.
59. WAIS FSIQ	132.1	6.6	144.	137.5	132.0	126.0	122.
60. WAIS VIQ	130.5	5.8	142.	134.5	131.0	126.0	120.
61. WAIS PIQ	130.2	10.1	149.	140.0	130.5	123.0	105.
62. Miller Anal Raw Score	61.7	9.8	81.	67.5	62.0	53.5	41.
63. Miller Anal. Percentile	59.4	21.1	93.	75.0	60.0	41.5	15.
64. Engn. Anal. Raw Score	31.1	5.9	45.	34.5	30.5	27.0	21.
65. Eng. Anal. Percentile	59.9	23.0	99.	77.5	60.0	40.0	25.
66. Doppelt Reas. Raw Score	35.9	5.3	44.	39.0	36.5	34.5	22.
67. Doppelt Reas. Percentile	42.1	25.5	90.	60.0	37.5	27.5	0.
68. Ror. # Response	29.2	15.0	71.	38.5	25.5	19.5	10.
69. Ror. X R T Achrom Cards	18.8	15.6	79.	26.5	13.0	9.0	03.
70. Ror. X R T Chrom Cards	21.6	20.4	94.	8.0	26.5	13.0	04.
71. Ror. F + %	89.4	9.9	100.	100.0	89.5	84.0	63.
72. Ror. F %	46.9	16.5	87.	55.0	47.0	41.0	10.
73. Ror. A %	42.4	10.7	61.	52.5	41.0	33.5	25.
74. Ror. W: M	5.8	1.5	90.	7.0	6.0	5.0	20.
75. Ror. M: FM + m	5.3	1.6	8.0	6.0	5.5	4.0	1.0
76. Ror. FC: CF + C	4.5	2.3	9.0	6.5	4.5	2.9	1.0
77. Ror. # Shading Responses	4.4	2.9	10.0	6.0	4.0	2.0	1.0
78. Ror. H + A: Hd + Ad	5.7	2.3	9.0	7.0	6.0	3.0	2.0
79. Ror. M: C	3.6	2.0	9.0	5.0	3.0	2.0	1.0

averages. Perfect scores on three or four of the sub-tests were not uncommon for subjects having IQs in the top third of this group. Arithmetic, Picture Completion and Block Design were the tests on which perfect scores were most often attained.

The WAIS, particularly the Verbal sub-tests, did not provide a great deal of high level differentiation for intellectual qualities in the Verbal area. Separation occurred in the Performance sphere. The WAIS was a valuable asset to the test battery because it provided a cross section of 11 samples of behavior. In several cases the Performance segment of the WAIS was of significant diagnostic value in pointing up difficulties in some candidates which had not previously come to light.

The aptitude and achievement tests demonstrated greater differentiation among the subjects. The percentile scores ranged from 15 to 93 on the Miller, from 01 to 90 on the Doppelt, and from 25 to 99 on the Engineering Analogies. This distribution of scores would be expected for a group with this background and experience.

The tests of intelligence and aptitude generally all correlate with one another. The Full Scale IQ and the Miller Analogies and Doppelt Mathematical Reasoning tests correlated significantly. The Engineering Analogies Test was the only measure of intelligence or aptitude to demonstrate a statistical relationship to other classes of instruments in the battery.

The scores for the Edwards Personal Preference Schedule and the

Gordon Personal Profile are based upon an Air Force population because previous experience with comparable groups has shown that a flying officer population tends to be quite different on several of the scales from either the college or general adult male groups reported by Edwards and Gordon. When scores from pilots are evaluated in terms of the usual civilian norms, all pilots give the same profiles. Unless correction is made for the uniqueness of this pilot group, it is impossible to reach any conclusions about individuals within the space pilot group.

The magnitude of the differences in some of the personality scales when flying officers and the space pilot group are compared with a college population is well illustrated by figure 2. It will be observed that a standard operational flying officer scores much higher on the Achievement, Dominance and Endurance motives, as well as manifesting significantly greater needs for Deference and Change. At the same time the Air Force group tends to show less Abasement and Nurturance.

Examining the difference between the first and third quartiles in table I one notes a considerable shrinkage in the range of the scales. In all but one scale of the Edwards and Gordon space pilot the group fell within 15 percentile points of one another. It was nearly impossible to make differentiations among the subjects based on these scores.

Among the 15 Edwards and the five Gordon scales, 21 significant

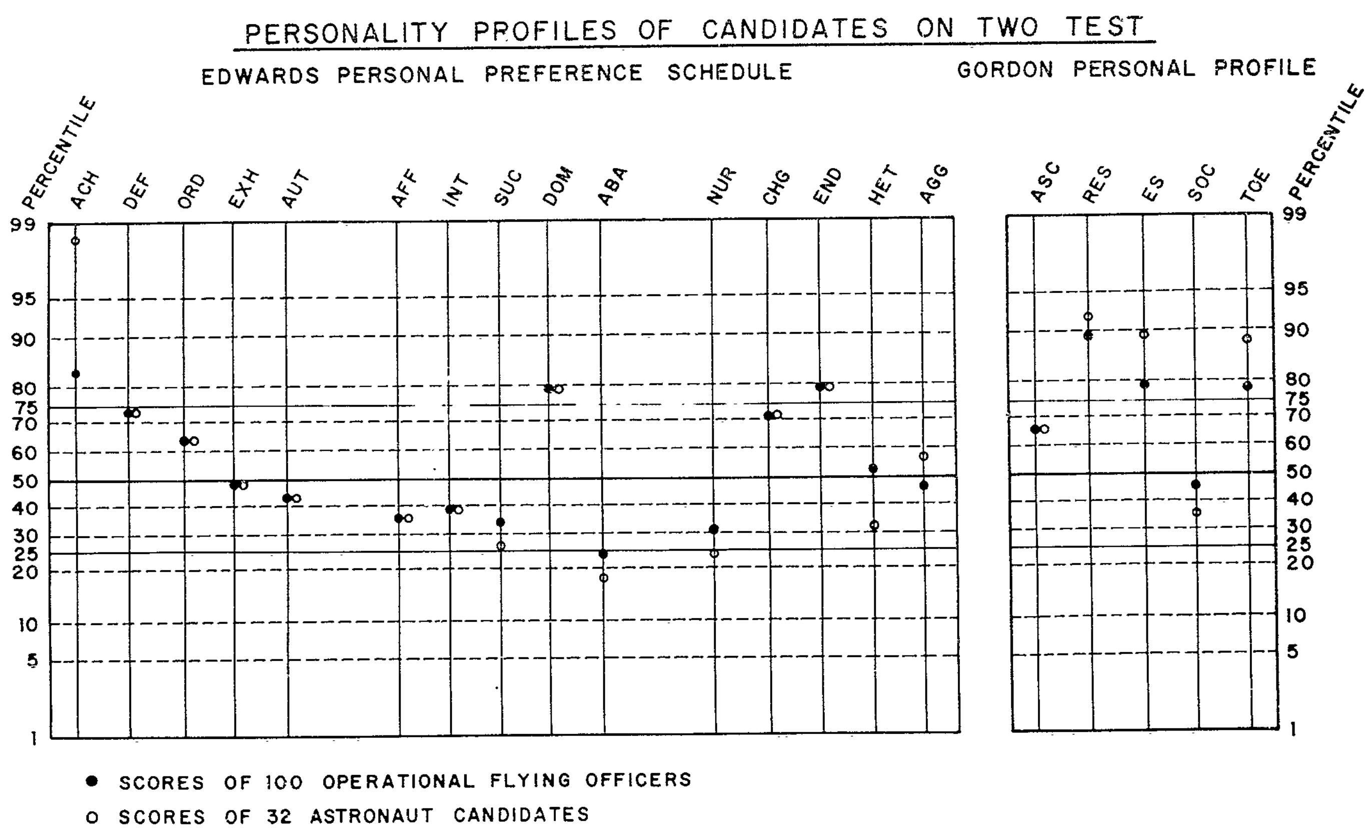


FIGURE 2

Personality profiles of space pilot candidates on the Edwards personal preference schedule and the Gordon personal profile. Scores have been converted to percentiles using tables for college students and then plotted to show the systematic difference between normal profile for students and profiles for space pilots.

correlations were obtained. On these 21 correlations which were significant at the .01 level or better, nine are intra-instrument correlations and approximate those previously reported. The inter-test instrument correlations are the most interesting, though these are the most likely to have occurred by chance. While it is not possible to calculate the number of chance correlations in a 79 x 79 matrix because the true correlation of all scores with one another is not known in each case, a large number should be expected. It is reasonable to accept Cronbach's (4) suggestion that a .01 level of confidence be obtained before a correlation is considered significant.

There were some correlations between a few of the Edwards' scales and the Rorschach that appear logical. The two most obvious are the positive relationship between the Heterosexuality and Aggression scores and the number of sex responses. A second significant finding of interest is the negative correlation between Deference and the FC:CF+C ratio. This means that a preponderence of FC over CF+C is related to high Deference scores, which is in keeping with Klopfer's (2) hypothesis about FC being an indication of social control. The other significant correlations between the personality inventory and Rorschach components were less meaningful.

The projective test material is very difficult to report in terms of quantitative or descriptive findings. The Bender Visual Motor Gestalt and the Draw-A-Person tests are good examples of this.

No abnormal productions were revealed during the performance proper of the Bender; during the recall session which occurred approximately 75 minutes later, the average number of correctly remembered figures was 7.5, with the range being 5 to 9.

The Thematic Apperception Test tended to be a measure of verbal and ideational fluency. The candidates' stories were generally longer than from the average pilot population. The competitive nature of the examination possibly influenced the length of their stories. Themes of achievement and autonomy prevailed, with aggressive stories less frequent. The achievement and autonomy needs seemed to be inter-entwined. For example, the modal story to Card 1 was of a boy being forced to play a violin, about which he has mixed feelings. As an outcome, the boy became successful and his parents were proud of him, even though his achievement was in another sphere. The stories of the candidates to Cards 4 and 7BM were similar to the Card 1 narratives. Modal themes in these cases involved being advised on a course of action (sometimes being physically restrained in Card 4); this advice is considered by the hero who then decides on his own course of action. The outcome was nearly always positive. In spite of the independence-autonomy themes, the actions of the heroes tended to be tempered by a strong predisposition to internalize the major values and wishes of authority figures.

The candidates' stories demonstrated good means-ends cognizance. In most cases the hero set a goal, or internalized the goal of a significant authority figure, selected a course of action to attain the goal, and persevered to the successful attainment of this end. The acquisition of specific facts was an important facet of each narrative. As a corollary of these stories were themes depicting the emphasis upon work and perseverance. These themes were very prominent throughout all of the protocols. The candidates' dedication to a task and their persistence in achieving a resolution were quite well-exemplified in that the majority of these stories contained a solution. Only in a few instances were situations left dangling. Aggressive themes were usually handled in a rather impunitive manner with direct aggression toward the environment only present in a few instances. The themes generally suggested these candidates handle their aggressive feeling by intellectually minimizing its effect and by logical reasoning.

A summary Rorschach profile for the 32 space pilot candidates is shown in table II.

Though the Rorschach profile varies somewhat from what has theoretically been proposed as an ideal Rorschach "psychogram" by prominent authorities such as Klopfer (5) or Beck (1), it generally conforms well to the other normative literature (2, 3). The candidates did not differ much from the profile reported for bright mobile individuals of the same age range found in industry. They were probably more like businessmen than any other single group.

This group is perhaps more extratensive and energetic than usual

TABLE II

COMPOSITE RORSCHACH PROFILE FOR 32 SPACE PILOT EVALUEES

Rorschach Factor	Approximate Mean*	Range
R	29	10-71
$\overline{X}$RT	20	4-87
W	10	2-24
D	14	0-35
d	2	0-13
DdS	3	0-26
M:FM+M	3:6	8:3 - 1:11
W:M	10:3	7:7 - 14:1
M: C	3:3	7:1.5 - 2:8
FC:CF+C	1:3	3:0 - 1:5
No. shading	4	0 - 10
F+%	89	63 - 100
F%	47	10 - 87
A%	42	25 - 61
H+A:Hd+AD	8:3	14:37 - 16:0
No. Content	10	6 - 14
Pop	7	3 - 13

*Rounded to nearest whole number

in a "normal" sample of men of comparable age and experience. There are signs of adequate control and the capacity for self-direction with the integration of impulse material in the service of long term goals. They tend to be somewhat sensitive, mildly anxious individuals who are very alert to what goes on about them, and who have the emotional capacity to respond appropriately to external affective stimuli.

The components of each test instrument correlates significantly most often with the components of the same test and only occasionally with other measures. The Rorschach is no exception. Of the 94 significant r's that emerge only 19 are related to scales of other tests.

<u>The Complex Behavior Simulator Performance Test</u>: A complex task is used to simulate the job characteristics of systems operators tasks. It utilizes a Complex Behavior Simulator (CBS) developed in this laboratory in combination with an information-processing task (AUDIT). The information processing task requires a continuous auditory monitoring and processing of signals by presenting single-letter Morse code signals in random order at a rate of one letter every five seconds. The subject's task is to monitor the different code letters being presented and to signal, by means of push-button switches corresponding to each code letter, whenever he has heard a specified number of a particular letter. In this particular application the subject monitored three code letters (A, N & M) and reported whenever he had received three of any one of them. Due to the small amount of practice

time available, the subjects were given a mnemonic aid for monitoring the signals.

This stress-testing was allocated one hour per subject. The subject received standardized instructions and practice on the task. Practice periods included an opportunity to perform on each task separately and then both together. Practice sessions were carefully monitored to insure adequate performance by the subject with coaching where indicated. The criterion for satisfactory base rate performance on CBS was a subjective evaluation by the examiner based upon signal handling rate and observed control movements. Criterion for adequate AUDIT performance was 100% signal recognition and five successively correct identifications of randomly sequenced three-signal series. All subjects met the above criteria within the time allowed except two who were allowed an extra 1 to 1-½ minutes to achieve the criteria on AUDIT.

Performance on the Complex Behavior Simulator was evaluated in relation to the scores of an "ideal" subject. Measures of proficiency (based on response time) and efficiency (based on the number of signals processed) were derived for each subject. On the average, this special group showed a decrease of 23% in efficiency and ain increase of 16% in proficiency, values generally like that demonstrated by the "ideal" subject. A procedure to combine all form measures into a single score was developed, and a rating and rank based on this score was derived. Table I, presented earlier, contains data on all these measures in detail.

In addition, an auditory tracking task is administered in conjunction with the hypoxia procedure during EEG studies. Hypoxia is an activating procedure during the routine neurological evaluation. Each candidate breathes an oxygen-nitrogen mixture containing approximately 8% O_2 for four minutes. The combination of procedural factors such as nose clamps, a mouth piece, and other attachments, together with the physiologic stress of relative hypoxia produced a situation in which stress-tolerance could be assessed.

Earlier studies utilized the same situation to assess stress-tolerance. These studies involved more stressful procedures, and demonstrated:

a) Marked individual differences in tolerance for physiologic stress, with some subjects showing large performance decrements when the physiologic indices suggested only minimal levels of physiologic insult.

b) Moderate individual differences in tolerance for the procedures themselves irrespective of the physiologic stress.

c) Observable motivational differences, directed toward the EEG evaluation as a whole, and reflected in tracking scores more directly than any other way.

These findings suggested that tracking during the hypoxia procedure would be a useful assessment technique.

The tracking test is administered as follows: Subjects are fitted with an earphone through which was fed a 600 cycle tone varying in intensity in a sinusoidal fashion at the rate of 30 cycles per minute. Their task is to rotate a potentiometer mounted on a bracket placed close to the subject in phase with the signal in order to cancel the variation in signal intensity. Perfect performance produced a barely detectable steady tone. A scoring circuit accumulated error during each cycle, and read it out as a deflection on a recorder. Each two-second cycle appeared as a spike on the recorder with a magnitude equal to the sum of the subject's error during that cycle. The task, though simple, requires constant attention and continuous responding.

Before the EEG evaluation began, the task is explained and demonstrated. Each subject was then given two minutes of practice, after which the earphone and potentiometer were removed. Approximately one hour later, after all preparations for the hypoxia procedure have been completed, the earphone and potentiometer are returned to the subject, and the instructions are repeated. Tracking starts 30 seconds before the subject begins breathing the low O_2 period, and extends 30 seconds into a recovery period while the subject breathes 100% O_2.

Average error per cycle for each 30 second period is computed from the error record. The tracking rating is arrived at subjectively by considering error scores and the apparent extent of physiologic insult, based on the amount of slow wave activity in the EEG record. For example, a candidate showing minimal slowing and minimal error receives a high rating, but a candidate showing marked slowing early in the run with moderate error could also receive a high rating. Initial plans included using motivational factors in arriving at the rating, but so little variability on this dimension was present that this consideration has been dropped.

The distributions of scores, both error and rating, were notably flat. The range of error scores was from 0.2 to 5.6. The upper limit for average error was 12 if the candidate did no tracking at all. The range of ratings was 1.2 to 6.0, with the limits of the rating scale being 0.0 to 6.0. The quartile values for the two sets of scores are shown in Table III.

These percentiles indicate effective internal discrimination for the test. They also suggested a marked correlation between average error and ratings. The correlation between these two scores was .85, which is significant at the .01 level. On the other hand, there were no significant correlations between either of these scores and any other score or rating obtained in the psychologic or psychiatric evaluation.

DISCUSSION

The technique employed in the psychiatric and psychological evaluation of space pilots has been described. The findings of the evaluation of 32 consecutive evaluees have been presented in some detail and discussed.

TABLE III

PERCENTILE SCORES FOR TRACKING STRESS TEST

	error score	error rank	rating score	rating rank
25th % ile	1.0	8	4.4	8.5
Median	1.65	16	3.8	16
75 % ile	2.35	24	3.0	24

Until frequent aerospace flight occurs, it will not be possible to evaluate the effectiveness of psychiatric and psychological assessment. However, a judgment can be made at present about the reliability and effectiveness of some of the techniques and concepts that have been used. For example, it is clear that the two paper and pencil personality inventories were of minimal discriminative value for this group. It is therefore unlikely that they would be of any significant value in predicting performance in an operational criterion situation. In the psychiatric rating scales, the psychiatrists' ratings indicated that no pathological defenses were present in the applicants, and since no discrimination is provided, these variables can be dropped.

From experience to date, it appears that the pre-screening afforded by the basic eligibility criteria for space pilots has resulted in the elimination of individuals with significant emotional problems. The applicants seen to date, while relatively homogeneous in terms of operational background and intelligence, have represented a wide range of personality characteristics. Nevertheless, with rare exceptions, they have demonstrated an extremely high level of personality functioning and adaptability. However, as larger numbers of pilots are required for participation in space programs, the level of experience for applicants will probably be modified. As a result, the psychiatric and psychological evaluation should assume increasing importance. The experience being gained in current evaluations can be expected to increase the effectiveness of future psychiatric and psychological aeromedical evaluations.

ACKNOWLEDGEMENT

The participation of the following professional and technical personnel is gratefully acknowledged: Major Charles L. Jennings, Captain Earl H. Cramer, Captain David Meltzer, Captain Mark A. Nessel, A/3C John C. Corbett, Jr., A/1C Richard I. Cordrey, A/3C Ronald A. Zophy, A/2C Ferdinand N. Runk.

REFERENCES

1. Beck, S. J., et al. The normal personality as projected on the Rorschach test. J. Psychol., 1950, 30, 241-298.
2. Brockaway, A. L., Gleser, F. L., and Ulett, G. A. Rorschach concepts of normalcy. J. Consult. Psychol., 1954, 18, 259-265.
3. Cass, W. A. and McReynolds, P. A contribution to Rorschach norms. J. Consult. Psychol., 1949, 46, 393-432.
4. Cronbach, Lee J. Statistical methods applied to Rorschach scores. Psychol. Bull., 1949, 46, 393-432.
5. Klopfer, Bruno, et al. Developments in the Rorschach Technique. Vol. I, New York: World Book, 1954.
6. Sells, S. B., and C. H. Berry. "Human Requirements for Space Travel." Air University Quarterly Review, 10, No. 2, 1958, Hq. AU, Maxwell AFB, Alabama.

PULMONARY EVALUATION

Carlos O. Welch, Jr., Capt., USAF, MC

and

Lawrence E. Lamb, M. D.

Most of the emphasis on pulmonary function studies was given to the maximal breathing capacity and vital capacity. Wherein applicable the pulmonary function studies have been compared to the VA standards. In addition five young athletes in training for the Pentathlon event were evaluated and the results of these studies are included for comparison of the space pilot candidates' studies to those of a well-trained endurance athlete.

The actual vital capacity for 65 space pilot ranged from 4,121 cc. to 6,900 cc. By comparison the values from the Pentathlon group varied from 5,508 cc. to 6,343 cc. Over half of the values from the space pilot were below the lowest value obtained in the five athletes.

The maximum breathing capacity ranged from 103 liters per minute to 242 liters per minute in the space pilot evaluees. The values for the five Pentathletes ranged from 151 to 190 liters per minute. The highest value in the space pilot evaluees greatly exceeded the highest value obtained in the Pentathletes.

The timed vital capacity and other ventilatory measurements are included in the accompanying tables.

Table I

Ventilatory studies in space pilots

	Actual VC cc's	Pred VC (VA)	% of Pred VC	Actual MBC L/min	Pred MBC (VA)	% of Pred MBC	TVC in %			IRV cc's *	ERV cc's *	TA cc's *	Diff vs Comp & SB VC cc's	Min Vent L/min	O_2 Consumption cc/min	Vent Equiv	Breath Res %	AV Index
							1 sec	2 sec	3 sec									
Lowest	4121	4240	86	103	158	59	59	68	74	1774	483	332	0	2.9	200	1.0	94	.60
First quartile	5058	4840	101	146	171	83	71.25	88	94	2900	827.75	582	86.25	4.6	275	1.49	96	.87
Median	5375	5090	107	167	177	94	75.5	91	96	3160.5	968	700	194	5.1	290	1.65	97	.93
Third quartile	5758	5228	113.75	189	180	107	79.75	95	99	3494	1251	854	290.75	5.7	317	1.99	97	1.01
Highest	6900	5580	136	242	191	130	94	100	100	4719	2258	1505	734	10	450	3.77	99	1.25
Mean	5407	5023	107.4	168.4	175.6	95.7	75.1	91.1	95.7	3183	102.6	716.4	210	5.2	300	1.76	97	.892
Number of subjects	65	65	65	64	64	64	65	51	51	49	49	49	49	49	49	49	49	64

* Supine

Table II

Pentathletes maximal breathing capacity

	Actual MBC L/min	Predicted MBC (VA)	% of predicted (VA)
1	165	185	89
2	163	183	92
3	151	188	80
4	173	192	90
5	190	192	99
		1.34 x Ht_{cm} minus 1.26 x Age minus 21.4	

Table III

<u>Pentathletes vital capacity</u>

	Actual VC cc's	Predicted VC (VA)	% of predicted (VA)
1	5832	5240	111
2	5508	5000	110
3	6074	5290	115
4	6343	5360	118
5	6288	5510	114
		.052 x Ht_{cm} minus .022 x Age minus 3.6	

Table IV

Timed vital capacity for 65 space pilot evaluees

	< 60%	60 - 69%	70 - 79%	80 - 89%	90 - 95%	96% +	Normal
1 second	1	7	40	16	1	0	70%

Timed vital capacity for 51 space pilot evaluees

	< 60%	60 - 69%	70 - 79%	80 - 89%	90 - 95%	96% +	Normal
2 second	0	1	0	17	23	10	90%

Timed vital capacity for 51 space pilot evaluees

	< 60%	60 - 69%	70 - 79%	80 - 89%	90 - 95%	96% +	Normal
3 second	0	0	1	1	18	31	Near 100%

CARDIOVASCULAR EVALUATION

Lawrence E. Lamb, M. D.

and

Robert L. Johnson, Lt. Col., USAF, MC

Each evaluee receives a comprehensive history and physical directed toward the cardiovascular area at the time of his complete examination by a specialist in Internal Medicine. It is rare that significant physical findings related to this area are noted on such an examination other than the occasional finding of moderate obesity. Functional murmurs and other physiological variations are not infrequently noted on cardiac auscultation.

Particular attention is given to blood pressure determinations since it has been suggested that moderate elevations may predispose to subsequent disease. In 65 successive candidates, in no instance has persistent elevated diastolic pressure been noted. Since the subjects are prescreened it would not be likely that this would occur. In an examination battery for one group of 32 subjects one individual demonstrated significantly elevated blood pressure. On the initial determination the diastolic pressure was 90 mm. Hg and during a 3-day pressure check both abnormal and normal readings were obtained. He had had a past history of difficulty in passing annual medical examinations because of intermittently elevated blood pressure. This laboratory classifies such individuals as clinical vascular hyperreactors. In our experience such fluctuating elevations of blood pressure are not necessarily associated with subsequent significant cardiovascular disease although they may be. Fluctuations from normal to abnormal in blood pressure in healthy, well-motivated, hard-working individuals is not exceedingly rare. Comparing the diastolic blood pressure values in 32 successive candidates, the following information was obtained:

Lowest value	124/64 mm. Hg
First quartile	125/70 mm. Hg
Second quartile	120/75 mm. Hg
Third quartile	128/80 mm. Hg
Maximum value	136/90 mm. Hg

Cold Pressor Test: This test is performed in the standard manner. The blood pressure is recorded until three or four stable readings are obtained. The subject places the left hand in ice water. The electrocardiogram is recorded continuously and blood pressures are determined. After one minute the hand is removed from ice water and records are obtained for two minutes after the removal of the hand from ice water. Individuals in whom the rise in diastolic pressure after immersion of the hand in ice water is less than 10 mm. Hg are classified as hyporeactors, those with a rise between 10 and 20 mm. Hg are called normal reactors and those with a rise exceeding 20 mm. Hg are classified as vascular hyperreactors in the traditional fashion. The values obtained by this test in this group of subjects frequently appear to be unrelated to the clinical blood pressure determinations. In 32 successive candidates they were as follows:

Vascular hyporeactors	15
Vascular normal reactors	10
Vascular hyperreactors	7

Plethysmography: An impedance plethysmograph is used for this procedure. The plethysmographic tracing is the result of changes in impedance between two electrodes. These are recorded between the upper and lower positions of each of the four extremities. This test is used primarily to note the characteristic of the curves as well as to objectively document normal bilateral equal pulsations for subsequent comparative data.

Phonocardiography: A standard twin-beam phonocardiographic instrument is used with recordings at the standard valvular areas being recorded in inspiration, expiration, and mid-inspiration. Evidences of minor variations without clinical significance, such as physiological systolic murmurs, are occasionally noted. In a highly selected population without clinical evidence of valvular disease or other form of cardiovascular disease, the phonocardiogram's use primarily is to establish baseline interval values by the simultaneous recording of one lead of the electrocardiogram with the mechanical events. In individuals in which there is any question of a significant cardiac murmur, the auscultation is carefully carried out in an acoustical soundproof room.

Ballistocardiography: A simple ballistocardiographic procedure is carried out with the simultaneous recording of electrocardiogram, phonocardiogram, and respiration. The air-suspension ballistocardiographic instrument is used. Adequate normal values and the clinical implication of the data obtained has in our opinion not been sufficiently validated. This procedure is done to provide future information for individuals particularly interested in this area as related to cardiovascular function and to establish normal values for an apparently healthy population.

Valsalva: A standard Valsalva procedure is carried out in all evaluees with each subject taking a very deep breath and bearing down firmly against the closed glottis as long as possible. The electrocardiogram is recorded throughout this procedure and blood pressure determinations are obtained at regular intervals using the ordinary manual method. This procedure is useful in terms of integrity of reflex control of the circulatory system as well as identification of significant cardiac arrhythmias which occasionally occur with such a procedure.

Electrocardiogram: The standard 12-lead electrocardiogram is recorded in all individuals. Since the majority of the candidates being evaluated for these missions have had previous electrocardiographic studies, significant electrocardiographic abnormalities have not been noted. Minor variations are observed; to illustrate, in 32 consecutive candidates, one individual showed nonspecific T wave changes which demonstrated appreciable lability and were reasonably persistent. They appeared to be unassociated with any clinical entity. The other aspects of his cardiovascular evaluation were entirely normal. Another individual demonstrated multiple premature contractions, atrial, nodal, and ventricular, without apparent cause. The most frequent findings noted in a highly selected population of this type are minor arrhythmias and nonspecific T wave changes.

Precordial Map: A precordial map is performed on each individual. This is done beginning with the second right intercostal space and extending as low as the sixth right intercostal space. Such a carefully done map provides early in the program identification of those individuals with R' waves and other minor electrocardiographic variations which may be recorded from time to time as related to electrode position. It provides a more adequate baseline for future comparison of chest leads in subsequent examinations. The infant precordial electrodes are used to avoid overlapping of electrode locations.

Vectorcardiography: An electrically balanced bipolar vectorcardiographic reference system is used in all subjects. In addition to obtaining the photographic representation of the frontal, sagittal and transverse plane, the vector components are recorded on magnetic tape for subsequent analysis by an analog computer; by the latter technique linear vectorcardiograms are obtained. The electrically balanced reference system permits more adequate evaluation of minor electrocardiographic variations, such as Q-3 patterns. The three-dimensional representation permits subsequent analysis of electrocardiographic variations associated with position or variabilities of the QRS in in-flight circumstances. To date no abnormal vectorcardiograms have been detected in the space pilot evaluees.

Master's Exercise Tolerance Test: A double Master's exercise tolerance test performed in a standard manner is obtained on each evaluee. Only significant plateau ST segment depression two minutes after exercise is considered as a positive criteria. In examination of over 60 space pilot evaluees and in the evaluation of test pilots over approximately a four-year period, no abnormalities in this test have been detected.

Special Electrocardiographic Studies: Each evaluee has an electrocardiogram recorded during a series of physiological maneuvers. These include recording during the sitting position as opposed to the recumbent position, maximum breath holding, carotid sinus massage, simple standing for orthostasis, and hyperventilation followed by maximum breath holding, and while seated inhalation of 100 % oxygen for 10 minutes at a regulator setting of 43,000 meters (approximately 11 mm. Hg). This battery of physiological maneuvers are carried out to demonstrate the dynamic variability as well as providing a more definitive basis to evaluate minor electrocardiographic variations such as nonspecific T wave changes and various cardiac arrhythmias.

These procedures have been developed within this laboratory and used by our group for approximately six years. Some of these same stresses are utilized during tilt table studies. Their repetition without the tilt table provides a means of identifying the added influence of the tilt table itself.

To illustrate the frequency of findings in 32 successive candidates, three individuals during breath holding and hyperventilation with maximum breath holding demonstrated transitory intermittent A-V dissociation. One individual showed a very transitory cardiac arrest with carotid sinus stimulation. Still another individual prone to have prematurities demonstrated frequent ventricular prematurities, atrial premature contractions and transitory A-V dissociation during the ventilatory stresses. The latter individual also experienced symptoms of the nature commonly seen with impending syncope. Electrocardiographic variations produced with these varieties of stresses are not given the same significance as if they were observed in the resting baseline electrocardiogram. The influence of the autonomic control of the cardiac rhythm and electrocardiographic patterns is so significantly altered during such stresses that their direct application to clinical diagnosis must be regarded with skepticism. More commonly they demonstrate individual physiological variations. To illustrate, simple physiological intermittent A-V dissociation in young, healthy, active individuals without apparent disease has no practical significance. This has been repeatedly borne out by extensive studies in the Air Force flying population over a period of many years. Should an individual be detected with unusual susceptability to minor respiratory maneuvers or minimal amounts of orthostatic stress, further evaluation is indicated with particular attention to the integrity of the autonomic nervous system and susceptability to recurrent loss of consciousness, including g tolerance.

Tilt Table Studies: These procedures are carried out on a specially designed tilt table. It is designed so that the subject is strapped to the tilt table by use of an ordinary parachute harness. The feet are suspended so that they cannot provide any form of support to the body. The use of the parachute harness and straps are so arranged that the tilt table can, in fact, be tilted either feet-down or head-down at will. The changes in position may be brought about in sufficiently rapid manner to be considered almost instantaneous or they may be managed at a slower rate if so desired. The table is so designed that it may rotate continuously through an arc of 360°. This test is useful in assessing the adequacy of circulatory adaptative mechanisms, chiefly autonomic control, to minor simple changes in g stress (Fig. 1).

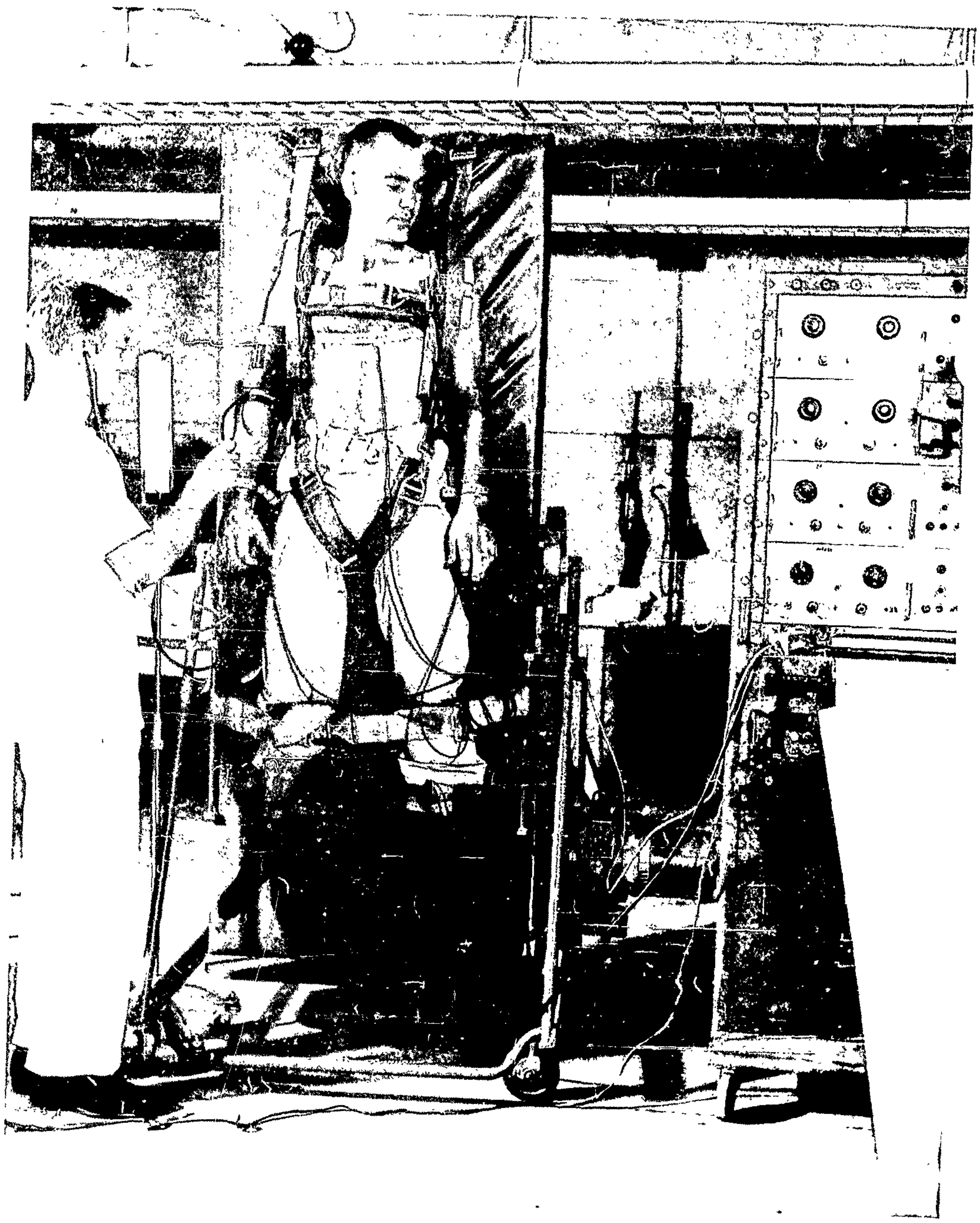


Figure 1: See text

Each subject is strapped to the tilt table and put in the horizontal position. Four successive baseline blood pressure determinations are obtained with the subject recumbent. He is then tilted 90°, feet down. For the subsequent 12 minutes electrocardiograms and blood pressures are obtained at each minute interval providing a period of 12 minutes of simple orthostasis. Immediately after this the individual takes a maximum deep breath. Breath holding is carried out through a period of one minute. He is permitted a recovery period after release of breath holding of approximately 3 minutes. After this there is a period of hyperventilation for 15 seconds followed by prolonged breath holding. The electrocardiogram and blood pressure are monitored at regular intervals throughout this procedure and again a 3-minute recovery period after the combined stress is allowed. In most examinations the test is terminated at this point.

It is to be noted that the test encompasses approximately 20 minutes of orthostasis, and by the gradual addition of subsequent stresses to the initial stress of orthostasis, accumulative factors which tend to decrease cerebral blood flow are initiated. In certain individuals and for special purposes following the stress period the subject is tilted head-down 45° for a period of one minute with electrocardiographic and blood pressure monitoring. The most common variation in electrocardiogram noted in healthy individuals during tilt table procedures are physiological T wave variations either induced by orthostatic stresses or a combination of orthostatic and ventilatory maneuvers. These are so frequent as to be the rule rather than the exception. Displacement of the cardiac pacemaker from the sinus node to an atrial position is also a frequent observation. In experience gained over several years utilizing this tool it would appear that young individuals, particularly those in the age group of aviation cadets are more prone to significant clinical responses to this combined form of physiological stress testing. Over 40 percent of young aviation cadets have been observed to lose consciousness at some point in this group of procedures in those tested within this laboratory. The older individuals appear to be less likely to represent such reactions.

In the group of 32 consecutive space pilot evaluees, three individuals showed cardiac arrhythmias including A-V dissociation in two subjects during simple breath holding and during breath holding following hyperventilation. One of these individuals also demonstrated premature contractions. Four additional individuals, in addition to minor cardiac arrhythmias and bradycardia, had clinical symptoms during breath holding following hyperventilation. These were the types of symptoms associated with decreased cerebral vascular blood flow or impending syncope. None

Each subject is strapped to the tilt table and put in the horizontal position. Four successive baseline blood pressure determinations are obtained with the subject recumbent. He is then tilted 90^{o}, feet down. For the subsequent 12 minutes electrocardiograms and blood pressures are obtained at each minute interval providing a period of 12 minutes of simple orthostasis. Immediately after this the individual takes a maximum deep breath. Breath holding is carried out through a period of one minute. He is permitted a recovery period after release of breath holding of approximately 3 minutes. After this there is a period of hyperventilation for 15 seconds followed by prolonged breath holding. The electrocardiogram and blood pressure are monitored at regular intervals throughout this procedure and again a 3-minute recovery period after the combined stress is allowed. In most examinations the test is terminated at this point.

It is to be noted that the test encompasses approximately 20 minutes of orthostasis, and by the gradual addition of subsequent stresses to the initial stress of orthostasis, accumulative factors which tend to decrease cerebral blood flow are initiated. In certain individuals and for special purposes following the stress period the subject is tilted head-down 45^{o} for a period of one minute with electrocardiographic and blood pressure monitoring. The most common variation in electrocardiogram noted in healthy individuals during tilt table procedures are physiological T wave variations either induced by orthostatic stresses or a combination of orthostatic and ventilatory maneuvers. These are so frequent as to be the rule rather than the exception. Displacement of the cardiac pacemaker from the sinus node to an atrial position is also a frequent observation. In experience gained over several years utilizing this tool it would appear that young individuals, particularly those in the age group of aviation cadets are more prone to significant clinical responses to this combined form of physiological stress testing. Over 40 percent of young aviation cadets have been observed to lose consciousness at some point in this group of procedures in those tested within this laboratory. The older individuals appear to be less likely to represent such reactions.

In the group of 32 consecutive space pilot evaluees, three individuals showed cardiac arrhythmias including A-V dissociation in two subjects during simple breath holding and during breath holding following hyperventilation. One of these individuals also demonstrated premature contractions. Four additional individuals, in addition to minor cardiac arrhythmias and bradycardia, had clinical symptoms during breath holding following hyperventilation. These were the types of symptoms associated with decreased cerebral vascular blood flow or impending syncope. None of these four individuals, however, lost consciousness. Still one other individual in the group of 32 subjects had frank loss of consciousness during these procedures. This individual was a highly qualified experienced test pilot of proved ability. He also appeared to have a higher index of susceptibility to syncopal responses following minimal stresses such as venipunctures. Despite his experience and unusually high qualifications, this susceptibility had never in any way appeared to have interfered with his ability to accomplish his flying duties.

The tilt table stress test is primarily used as a component part of studying adaptive responses; however, those individuals who show unusual susceptibility with loss of consciousness to minimal stresses should be regarded as less desirable candidates for entering into space pilot programs.

Lean Body Mass: The total body water is determined in each evaluee. Principally two methods have been used; one has been the deuterium method,* and the other has been the tritium dilution method.** Previous studies have indicated that these two methods are comparable. The subject's instructions

---

* Those individuals who received total body waters by the deuterium method have had their determinations done by the Biokinetics Laboratory, USAF School of Aerospace Medicine, Brooks AFB, Texas.

** These determinations were carried out under the supervision of Captain Fred Katz, USAF, MC, USAF School of Aerospace Medicine, Brooks AFB, Texas.

for this test are incorporated in his daily instruction sheet given to him at the beginning of his 5-day examination. From the determination of total body water and measurement of body weight, the percent of body fat and lean body mass can be calculated. The determinations are given in 63 subjects in Table I.

A reasonably accurate correlation between the height of the average adult male within a given age group and the lean body mass exists. This ratio (kilograms lean body mass/height in inches) has been calculated in 63 space pilot evaluees. The results are given in Table II.

This information provides a reasonably accurate means of estimating lean body mass of an individual within this age group. If the height in inches is multiplied by 0.86 the product is very close to the kilograms of lean body mass for a reasonably active subject.

Determination of percent of body fat in five Pentathletes demonstrated that only eight of the space pilot candidates had a percentage of body fat as low as those values seen in the pentathletes. The values for the five Pentathletes are given in Table III.

Blood Volume: This determination was accomplished by the use of radioactive isotope techniques. The I^{131} method was used. As is customary Lugol's solution was given the day prior to the testing. The results in 59 space pilot evaluees are given in Table IV.*

---

* These determinations were carried out under the supervision of Major Charles L. Randolph, Jr., USAF School of Aerospace Medicine, Brooks AFB, Texas.

Table I

Percent of body fat in 63 space pilots

Lowest	10.5%
1st quartile	16.9%
Median	20.6%
3rd quartile	24.4%
Highest	34.9%
Mean	21.06%

Table II

Kilograms of lean body mass/height in inches
in 63 space pilots

Lowest	0.71 kilo LBM/inches
1st quartile	0.83
Median	0.86
3rd quartile	0.90
Highest	1.05
Mean	0.86

Table III

Percent of body fat in five Pentathletes

Subject	% of body fat
1	6.4
2	8.9
3	12.0
4	12.5
5	14.1

Table IV

Total blood volume per kilo of lean body mass in 59 space pilots

Lowest	76.89 ml.
1st quartile	86.81
Median	92.75
3rd quartile	101.93
Highest	126.29
Mean	95.78

Maximum Oxygen Consumption: The maximum oxygen consumption for each candidate was measured during maximum physical exertion. This was accomplished by having the subject walk on a constant treadmill with a speed of 3.3 miles per hour (90 meters per minute) and gradually increasing the grade of the treadmill. The grade was increased 1% per minute (approximately 2/3 degree). The blood pressure was obtained at each one-minute interval throughout the procedure. An electrocardiogram was telemetered during exertion and a sample write-out obtained at each one-minute interval (Fig. 2). Near the end of the test minute samples of expired air were collected. These were subsequently analyzed for oxygen consumption per minute at each of these intervals. When the heart rate reached 180 beats per minute it was assumed that the individual was nearing maximum exertion. All individuals were permitted to continue exertion if they were not unduly fatigued and permitted to quit at any point after this. Some candidates continued until their heart rate reached levels of 200 beats per minute. Serial analysis of the minute oxygen consumption indicated that in many subjects the level of maximum oxygen consumption was indeed reached near a heart rate of 180 beats per minute.

The test was also terminated if the systolic pressure exceeded 240 mm. Hg or the diastolic pressure exceeded 140 mm. Hg. If the pulse rate began to drop or if there was a significant drop in blood pressure the test was terminated immediately. The use of maximum treadmill exertion

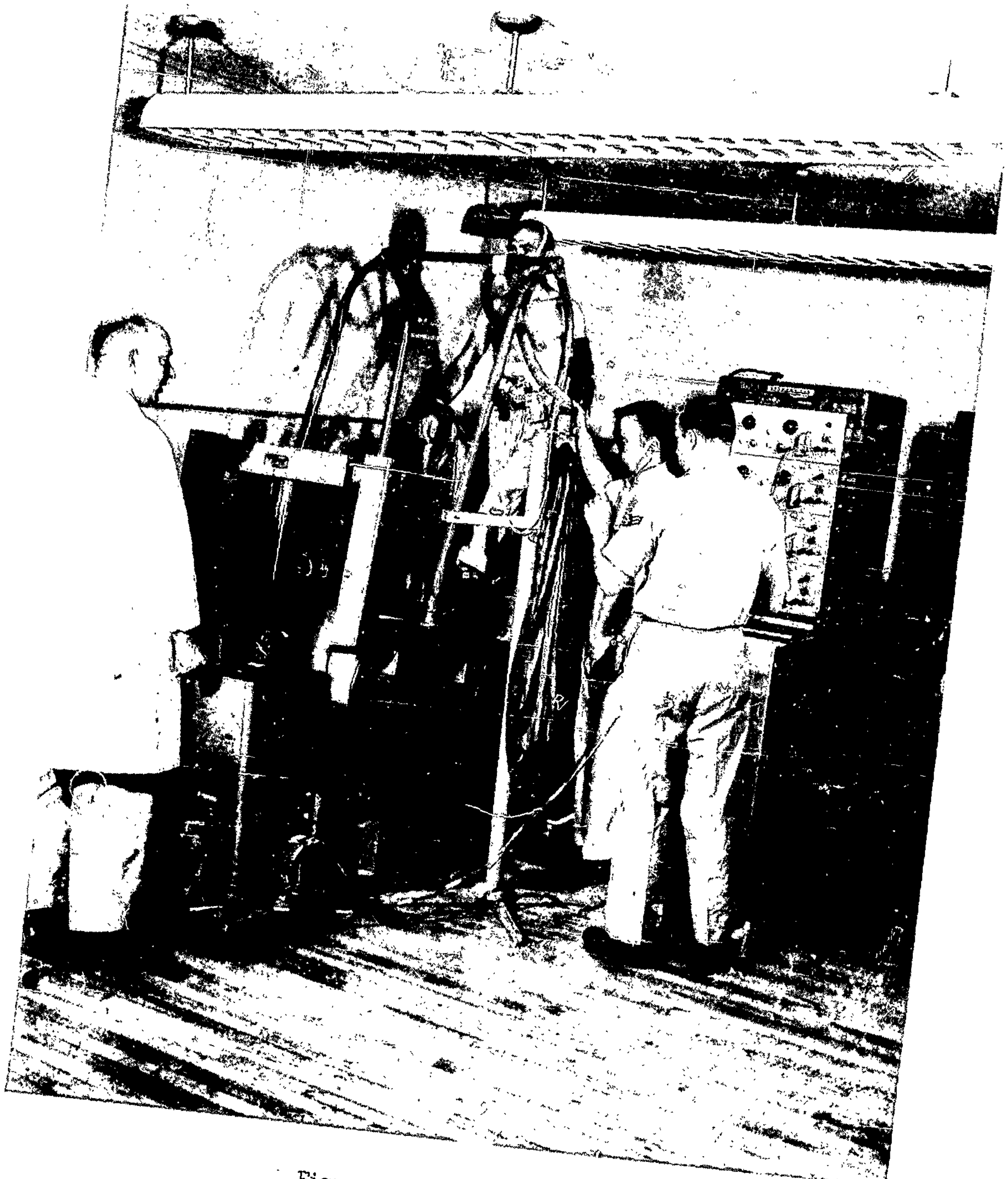


Figure 2: See text

has been used successfully in this laboratory in members of the flying population for over three years nearly as a routine procedure. Naturally, care is taken not to use excess exertion in individuals with frank cardiac disease. To date this has not posed a significant hazard. It is understood that young healthy individuals of the type examined for space pilot groups in many instances could exceed the amount of exercise done and have further increases in heart rate. Whether or not increased exercise would materially affect the maximum oxygen consumption values remains to be seen. In the absence of continuous monitoring of the oxygen consumption at the time the test is being performed, it was not thought prudent to extend the degree of exercise. For purposes of evaluation of performance during vigorous exercise the test is deemed adequate.

Other investigators have demonstrated by direct measurement that at the point of maximum physical exertion oxygen desaturation reaches the point that the oxygen content of the mixed venous return in the right atrium is approximately 5.0 cc.[1] The variation from this value is minimal if true maximum exertion has been achieved. This point is exceptionally useful as it provides a means for a gross estimate of cardiac output and stroke volume in the normal healthy individual at the point of maximum physical exertion. These estimated values are calculated in each subject. It is essential to know the hemoglobin content and the maximum oxygen consumption. The calculation is done as follows:

$$\text{Hemoglobin} \times 1.34 = O_2 \text{ capacity}$$

Example:

$$14.6 \times 1.34 = 19.56 \text{ cc.}$$

The oxygen content is calculated:

$$O_2 \text{ capacity} \times 97\% = \text{estimated oxygen content}$$

Example:

$$19.56 \times 97\% = 19 \text{ cc.}$$

The A-V oxygen difference (femoral artery - RA) = O_2 factor

Example:

$$19.0 \text{ cc} - 5.0 \text{ cc (estimated)} = 14 \text{ cc/100 cc of blood}$$

$$\frac{\text{Oxygen consumption}}{\text{A-V oxygen difference}} = \text{cardiac output}$$

$$\frac{\text{Maximum } O_2 \text{ consumption}}{O_2 \text{ factor}} = \text{estimated maximum cardiac output}$$

Example:

$$3780 \text{ cc} \div \frac{14}{100} = 27 \text{ liters}$$

$$\frac{\text{Cardiac output}}{\text{Heart rate}} = \text{stroke volume}$$

Example:

$$\frac{27{,}000 \text{ cc}}{180} = 150 \text{ cc (estimated maximum stroke volume)}$$

The results of calculation of maximum cardiac output and stroke volume were quite compatible with direct measurements that have been reported by others. A maximum stroke volume of 150 cc is about equivalent to the measured anatomical volume of the left ventricle in the adult male. It would be assumed that in those subjects that have estimated stroke volumes in this range that maximum diastolic filling and complete systolic ejection is achieved during maximum exertion. Clearly cardiac output and stroke volume are related to the oxygen consumption. The values for cardiac output and maximum stroke volume are included in Tables V and VI. The values obtained from the space pilot group can be compared to measurements taken from five Pentathletes, the latter are given in Table VII.

The maximum oxygen consumption is directly dependent upon the amount of blood pumped through the lungs. In normal healthy individuals at the point of maximum exertion the ventilatory requirements are far below values achieved during maximum breathing capacity. The limitation on physical exertion in young healthy individuals is frequently the limitation of the cardiovascular system's ability to supply blood to the lungs for oxygenation. It is thought by several investigators that the limitation on the heart in doing this is the limitation in coronary blood flow.[2] This concept is based on the principal that more or less complete oxygen extraction occurs at rest in the normal coronary blood flow; that is, the venous content of the coronary blood flow at rest is as low as 5 cc ; thus, increased

Table V

Estimated maximum cardiac output
in 62 space pilots

Liters/min.	# Subjects
Largest value (28.2)	
30-28.1	1
28-26.1	1
26-24.1	5
24-22.1	8
22-20.1	17
20-18.1	13
18-16.1	9
16-14.1	4
14-12.1	4
Total	62

Table VI

Estimated maximum stroke volume in 62 space pilots

c c 's	# Subjects
Largest value (155.0 c c)	
> 150 c.c.	1
150-140.1	2
140-130.1	4
130-120.1	7
120-110.1	12
110-100.1	16
100-90.1	10
90-80.1	3
80-70.1	7
Total	62

Table VII

Pentathletes cardiovascular function values

Subject	O_2/kilo lean body mass	Max. O_2 consumption	% body fat	Work factor	MOC/ work factor	Estimated Max. Cardiac output	Estimated Max. stroke volume
1	56 c c	3.70 L/min	12.5%	22853	16	28.1 L/min	148 c c
2	58	3.68	12.0	28122	13	27.9	152
3	52	3.56	8.9	17982	20	28.1	152
4	61	3.50	6.4	16200	22	24.5	138
5	58	3.40	14.1	16539	21	22.8	119

amounts of oxygen cannot be delivered to the heart muscle by further extraction of oxygen from coronary blood flow. The heart is a unique organ in the body in this regard; for example, the venous return in the resting recumbent individual from the legs has an oxygen content of approximately 13 cc and the arm approximately 14 cc. Increased oxygen supply for the cells in these areas can be achieved by increased oxygen extraction from the blood stream. The only way that the oxygen supply to the heart muscle can be increased is by increasing coronary blood flow; thus, during severe physical exertion in the normal individual there is dilitation of the coronary arteries accommodating increased coronary blood flow. It is equally apparent that when oxygen consumptions exceed 3 liters per minute that the increased delivery of oxygen to the cells cannot be accomplished by increased A-V oxygen difference. Under unrealistic circumstances the oxygen content of the arterial blood seldom exceeds 20 cc / 100 cc of blood. If all of this oxygen were extracted at a normal cardiac output of 5 liters per minute this would represent only 1,000 cc of oxygen delivered. Thus, it is impossible without increasing cardiac output to supply more than 1,000 cc of oxygen per minute to the body tissues. The actual figure for obvious reasons is appreciably lower, more nearly 750 cc per minute. Thus, the large values for maximum oxygen consumption measured directly during exertion can reflect little else but significant increase in cardiac output.

Multiple different measurements and correlations have been made from the various factors measured during maximum exertion. The factors most commonly considered have been the maximum oxygen consumption, the relationship of this value to kilograms of lean body mass, estimated amount of work performed, time required to reach maximum effort, and others. Only those which seem to have the greatest practical value will be included in this report.

The actual amount of work performed is dependent upon the body weight of the individual, the distance he travels and the increased work through time resulting from the progressively increased incline of the treadmill. To account for the increasing slope a formula was used to estimate a work factor. This formula was:

$$\left(\frac{t^2}{6} + t \right) wt$$

Where t represents time of exertion on the treadmill and wt equals body weight. This factor is at best an estimate since the amount of work performed is related to many physical factors. For example, it is easier for an individual with longer legs with a naturally longer stride to accomplish more work with a treadmill type of exercise. Actually, the maximum oxygen consumption in itself represents a work factor.

The maximum oxygen consumption per minute varied from 4.04 to 1.90 liters per minute in 61 subjects. The variations, quartiles and mean for the maximum oxygen consumption, the oxygen per kilogram of lean body mass, percent of body fat, work factor, and the ratio of maximum oxygen consumption/work factor are depicted in Table VIII. The heavy dark line drawn across this graph indicates the lowest value for the five Pentathletes. It will be noted that in all instances, except the ratio of MOC/WF, values for the Pentathletes were within the first quartile of those values obtained from the space pilot group. That is to say, the five Pentathletes were within the top one-quarter range of what is considered the most desirable values for all of these studies with the exception of the ratio of MOC/WF in which instance they were in the upper one-half.

In order that the reader may see the correlation between various factors, the values obtained in 61 space pilot candidates for a variety of different measurements are given in Table IX. The subjects are arranged in the order of their oxygen per kilogram of lean body mass. It is noted that the correlations between the factors are pretty general and it is difficult to draw any definite conclusions regarding the interrelationship of the different factors given.

In general, the maximum oxygen consumption can be regarded as an index of the actual amount of work performed. The fact that these values do not always correlate with the work factor calculated in this study reflects other problems related to training and that the work factor itself at best is an estimate. For this reason, the maximum oxygen consumption

Table VIII

Cardiovascular function studies in 61 space pilots

	O_2/kilo of lean body mass	Maximum oxygen consumption	% Body fat	Work factor $\left(\frac{t^2}{6} + t\right)$ wt	Maximum O_2 / Work factor
Best value	64 cc/min	4.04 L/min	10.5%	20,868	12
1st quartile	52	3.20	16.60	16,112	18
Median	49	2.96	20.30	12,947	22
3rd quartile	43	2.70	23.60	11,018	25
Poorest value	32	1.90	34.90	5,904	44
Mean	48	2.90	20.57	13,439	22.29

Table IX

Correlation of values during maximum exertion for 61 space pilots

O_2 cc/kilo-lean body mass	% Body fat	Maximum oxygen consumption	Work factor	Max. O_2 / Work factor
64	27.60	4.04	16435	25
61	13.76	3.70	18600	20
60	23.40	3.66	13825	26
59	34.90	3.40	12708	27
59	20.80	3.10	10296	30
59	26.50	2.82	13514	21
58	18.60	3.30	18480	18
56	16.90	3.10	16206	19
56	30.80	3.41	7790	44
54	15.40	3.40	15569	21
54	13.00	3.85	20520	19
54	22.60	3.06	10400	30
53	25.80	3.23	12960	24
52	21.00	2.80	12716	22
52	11.30	3.22	19995	16
52	19.00	3.04	13754	22
52	20.30	3.04	10514	28
52	24.40	3.10	9240	34
52	25.90	3.05	12240	25
51	14.90	3.60	20091	18
51	21.00	3.26	14141	23
50	16.60	2.90	12087	23
50	13.20	3.20	11895	26
50	19.40	3.04	11880	25
50	15.10	3.06	15356	19
49	10.50	2.70	12947	20
49	17.00	2.98	11880	25
49	14.90	3.00	12640	23
49	22.60	2.90	11018	26
49	23.80	2.90	14792	19
49	18.30	3.48	12480	27
49	17.00	2.90	12522	23
49	24.70	3.10	16920	18

Table IX (Continued)

O_2cc/kilo-lean body mass	% Body fat	Maximum oxygen consumption	Work factor	Max. O_2 / Work factor
48	18.60	2.80	17594	16
47	13.20	3.50	20868	17
47	20.62	2.96	13075	23
46	22.40	2.40	6560	36
46	31.80	2.60	9660	27
46	13.20	3.00	19620	15
44	23.50	2.80	13608	20
44	16.86	3.10	12415	24
44	24.90	2.80	13320	21
43	20.06	2.20	10530	20
43	13.20	2.77	16112	17
43	12.70	2.70	20124	13
43	32.60	2.80	10856	26
42	30.30	2.85	15480	18
42	21.60	2.45	9360	25
41	17.20	2.55	19990	12
40	17.10	2.50	14186	17
40	14.80	2.36	15785	14
40	22.70	2.27	10595	21
40	28.70	2.88	9184	31
39	22.50	2.40	12600	19
39	26.00	2.23	12240	18
38	23.60	1.97	5904	33
38	21.40	2.23	9653	23
37	19.90	2.30	17323	13
37	17.50	2.16	10855	20
33	25.40	2.14	19328	11
32	18.10	1.90	9389	20

value is perhaps the best index of work capacity performed during the test that is available. It is assumed that fatty tissues do not contribute in any way to the performance of the work and may be regarded as a pack or load. It is for this reason that the ratio of oxygen consumption/kilograms of lean body mass was used. This value expresses the work capacity per unit of cell mass. A very large man might have a fairly high maximum oxygen consumption. If he had a large lean body mass to do this amount of work the actual work per unit of cell mass might not be great. A smaller individual with a lower value for maximum oxygen consumption could actually be doing more work per unit of cell mass than the larger individual. The use of these two figures gives useful information in this area. The concept of work performed per unit of cell mass refers to lean body cell mass and not to inert fat tissue. It is recognized that fat tissue may play an appreciable role in metabolism under resting circumstances. This is not expected in the presence of maximum exertion; hence, the body has the capacity to shunt blood away from tissues that do not require large amounts of oxygen during maximum exertion. To illustrate, if the leg muscles are used primarily for exercise while the arm is placed at rest the blood flow to the arm will be significantly diminished to the point that the oxygen content of the venous return from the resting arm may fall to levels as low as 5 cc.[1]

The maximum oxygen consumption test appears to be a good procedure for measuring general physical fitness and endurance. It is not likely that an individual would achieve top values comparable to those within the first quartile without having very competent coronary blood flow. It should be emphasized, however, that this test by itself particularly in the medium ranges of values cannot completely exclude the presence of underlying coronary artery disease since it is well-known that individuals who have known coronary artery disease are capable of performing an appreciable quantity of work. Those points at which it can be stated fairly equivocally that coronary artery disease is not present and those values which are sufficiently low to cause suspect have not been defined. Our studies to date would indicate that there is an overlapping of values obtained in reasonably normal individuals as opposed to values obtained in individuals with known disease. Further studies in comparison with individuals with known clinical problems accompanied with longitudinal follow-up information will be required to evaluate this point. It can be stated, however, that those individuals who have values in the high normal group commonly represent those with the medical and physical features attributed to robust good health.

It should be stated that there are other factors besides coronary artery disease which may limit the maximum oxygen consumption, this includes the possibility of a left to right shunt mechanism or other forms of cardiac disease. It should be possible, however, on the basis of pulmonary function tests compared to the ventilation required during maximum exertion to differentiate with some degree of accuracy those limitations in exercise due to pulmonary factors as opposed to cardiovascular factors. Unusually low values should suggest the requirement for more searching clinical evaluation. To date the group with possible pathological findings that have shown the lower values are those individuals classified as clinical vascular hyperreactors, labile hypertension, or essential hypertension. Not all individuals with labile blood pressures present poor performance during such studies, some have good results. A low value, however, is not particularly uncommon in this group. These and other features of the maximum oxygen consumption test will be reported in more detail in another publication.

ACKNOWLEDGEMENTS

Appreciation is expressed to Dr. Robert G. Rossing for assistance in the performance of the clinical physical examinations; to SMS William Cherry, Jr., SSgt John St. John, SSgt Ralph M. Jackson and Mr. Ignacio Noguera who assisted in the tabulation and analysis of test results and to AlC Stanley Karwejna, AlC Mark Schaeffer, A2C Joseph Perry, A2C Amos Barnard and A2C David C. Hurt for technical support in accomplishing the various highly technical test procedures in the Cardiovascular Laboratory.

REFERENCES

1. Mitchell, J. H.; Sproule, B. J.; and Chapman, C. B. The Physiological Meaning of the Maximum Oxygen Intake Test. J. of Clin. Invest. 37:538-547, 1958.

2. Rushmer, R. F. Cardiovascular Dynamics, Second Edition. W. B. Saunders Company, Philadelphia and London, 1961.

RECOMMENDATIONS AND REPORTS

Lawrence E. Lamb, M. D.

The aeromedical evaluations of individuals for space pilots encompass the highly specialized skills of individuals from many different disciplines, each oriented in the application of his particular specialty to aerospace needs to provide the highest level of quality input into the final recommendations concerning each individual. All aeromedical variations or all findings of any significance are presented to a combined staff meeting in which the individuals representing all the disciplines discussed in the preceding sections are present. Out of such a meeting there is a free exchange of medical information concerning each individual evaluee. This insures that every finding is given thorough and competent consideration in the broad ramifications of its application to aerospace missions. Such a combined conference is particularly important in programs involving subsequent competitive selection in order to mitigate personal prejudices or personal enthusiasms. Such a conference gives added insurance that no biological variation of aeromedical significance will escape notice.

A comprehensive final report containing all of the essential ingredients of the evaluation is prepared on each subject. The final report consists of the diagnostic cover sheet, the aeromedical survey, the physical examination and referral data, followed by the various laboratory procedures discussed in detail in the preceding chapters, reported usually on standard formats, plus the discussion and recommendations of each specialty department. The final consultation in the report is prepared by the Department of Aviation Medicine which is responsible for integrating the aeromedical applications of the various findings and including appropriate administrative directions when indicated.

The completed record is then approved by the Chief of the Clinical Sciences Division and the Commander of the USAF School of Aerospace Medicine.

In conclusion, it should again be emphasized that despite the extensive scope of this examination it is not the opinion of the examining team, nor our intent, to be able to predict the future occurrence of disease or disability. Diagnostic tools and measurements developed in the medical profession are not at this date that sophisticated. There are no such examinations existing at this date. It is our intent to provide in the most comprehensive manner possible as thorough and searching an examination as can be permitted within the state of the art of medical diagnosis and examination at this time. Such an extensive examination has a greater probability of identifying individuals with outstanding excellence in physical and mental health. This examination, as would be required of any other procedure, can and will be modified when new significant advances are learned by the medical community which have direct application to the goals of this program.