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NASA CLINIC DIRECTORS, ENVIRONMENTAL
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ADVISORS**

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**Proceedings of the
ANNUAL CONFERENCE
of
NASA CLINIC DIRECTORS,
ENVIRONMENTAL HEALTH OFFICIALS
and MEDICAL PROGRAM ADVISORS**

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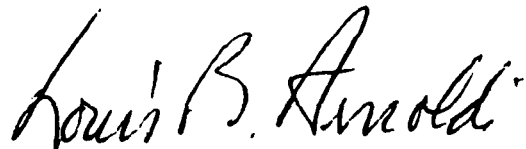
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PREFACE

The attached papers were presented to the attendees of the annual meeting of the NASA Occupational Medicine and Environmental Health personnel, held at the Hotel Roosevelt, New Orleans, Louisiana, October 21, 22, and 23, 1969.

Each Presenter was directly related to the NASA Occupational Medicine and Environmental Health Program, either as a full-time employee or as a consultant in a specialty.

The goals of the meeting were two fold; first, to bring to key personnel of the Agency the current status of the Occupational Medicine and Environmental Health Program, and secondly; offer the opportunity for individual program discussions and evaluations. Through this type of conference, it was hoped to realize technical improvement and program consistency of all Occupational Medicine and Environmental Health Programs within the Agency.



Louis B. Arnoldi, M.D.
Director, Division of Occupational
Medicine & Environmental Health

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APOLLO 11 IMPACT
on the Occupational Medicine Program
NASA Manned Spacecraft Center

presented by

Paul E. Wright, M.D., M.P.H., F.A.C.P.
Project Manager, Contract NAS 9-6568

Some time ago, when it was decided to quarantine the Apollo 11 crew members after their return from the lunar landing, it was realized that certain medical standards would have to be met for support personnel in the Lunar Receiving Laboratory (LRL), especially for those who would work within the biological barrier. Two things had to be considered. The medical people had to insure that the personnel could perform their functions properly, and some people would have to be excluded who might develop a serious illness within the quarantine area. Obviously, serious illnesses in quarantine would break the quarantine or cause some physician to have to enter for medical treatment of the patient, which would result in the physician being quarantined.

Dr. Wedum at Camp Detrick presented certain ideas, and a protocol was developed. The protocol for the occupational medicine support of the LRL consisted of examination procedures covering laboratory work, periodic examinations, immunizations, health maintenance, preventive practices, medical standards, and waiver authority. LRL personnel then were categorized: Category 1, people working within the biological barrier; Category 2, support personnel for the first group. Initially all were examined thoroughly, and two weeks before quarantine, Category 1 personnel returned for a premission examination. Immunizations were absolute requirements.

Meeting the requirements of LRL examinations within a time limit did have an understandable impact on the normal program of the MSC Dispensary. The services had to be changed, but the care of emergencies, some urgent job-related examinations, and attention to drop-ins continued as usual. Annual, voluntary screening examinations, offered every civil service employee, was the logical area for a change to meet these requirements. Generally, these examinations are given in the month of birth; however, since more birthdays fall in the July through October period, the patients were scheduled slightly ahead of their birth dates during the first of the year. Appointments were approximately one month ahead until March, when special examinations for the Lunar Receiving Laboratory were started. Last year every civil service employee, who volunteered, did receive a physical examination, but starting in May the schedule was reduced. As long as the LRL requirement exists, employees 30 years of age or younger will be examined every other year instead of annually.

The LRL examinees included MSC employees, contract employees, visiting scientists, related specialists, security, fire & safety, and maintenance men who could, for one reason or another, be required to enter the quarantine area or work within the biological barrier. The original estimate was that there would be a fairly limited number of examinations, which would have caused no great difficulty. However, the number of examinees grew and grew--like taxes and the cost of living. In all, more than 900 examinations were performed on over 600 individuals, so you can see, this disrupted the dispensary workload to a considerably degree.

Originally, difficulty was experienced with individuals making their scheduled appointments and in getting them back for follow-up examinations or additional immunizations, but later a successful system was developed with the cooperation of the Quarantine Control Officer (QCO).

Each medical chart, on LRL examinees, was reviewed by a dispensary physician, who determined whether or not that person was qualified physically to work in the area. Dr. Clarence Jernigan, Chief, Flight Medicine Branch, granted all waivers and notified the LRL QCO and the person involved.

Two procedures were added to the thorough examination. The laboratory did serum electrophoresis (immunologic pattern). Sixty days before the start of the mission, 50ml blood was drawn from each patient, and 25cc of serum was stored in the freezer for future reference. Additional electrophoretic patterns were accomplished after illness. It was also decided that LRL employees, working within the biological barrier and requiring corrective lenses, would be furnished safety glasses. So that no one would want to take them out of the area, Dr. Wedum suggested the ugliest possible frames be purchased. A lensometer was borrowed, and two physiological training technicians worked at the dispensary processing prescriptions for individuals who needed safety glasses. Even though the individuals were notified of this service, the response was slow, so the processing was reduced to one hour per day to avoid wasted manhours. This did present a few anxious moments. Because of the time necessary in processing and procuring glasses, there appeared a strong likelihood that a considerable number would not have their extra pairs of glasses in time for the scheduled quarantine for Apollo 11.

The initial examinations, premission examinations, immunizations, safety glasses, etc., generated a mound of paperwork. Lists were submitted daily of individuals who were either qualified, nonqualified, qualified with waiver, and incomplete examinations, which became an area of concern. This has been studied and will be simplified for Apollo 12. Computer printouts will be used as checklists for categorized LRL personnel to avoid the typing of list after list as the status of examinees changes from day to day.

~~TOP SECRET~~

The Mission Personnel Surveillance Program for the Apollo 11 mission and quarantine was handled by a physician from the U.S. Public Health Service and the Flight Medicine Branch. Toward the end of the quarantine it became an added responsibility of the dispensary personnel. The Mission Personnel Surveillance Program is a system to ascertain the nature of illnesses in personnel who are contacts of a mission crew, to establish, as soon as possible, an etiologic diagnosis for any illnesses possibly transmitted to the Apollo crew. Category 1 and 2 employees who were absent from work were contacted and asked to report to the dispensary for medical and laboratory evaluation. If that was impossible, the medical and laboratory evaluations were initiated at the patient's home. Epidemiological questionnaires were completed when the patient reported to the occupational health facility. The physician then indicated the specific laboratory samples to be taken for culture, as well as samples for blood count, urinalysis, etc., as indicated. The same arrangements were made for the non-LRL control group.

As the Apollo 12 mission so closely follows Apollo 11, it is planned to combine the 60-day post quarantine examination for Apollo 11 and the premission examination for Apollo 12, on those people listed in Category 1.

MEDICAL EXAMINATIONS FOR RADIATION WORKERS

R. E. Alexander
Manager, Radiological Health
Environmental Health Branch
Division of Occupational Medicine and Environmental Health
NASA Headquarters

The NASA radiological health program will be developed in consonance with a basic radiological protection policy. According to this policy, an employee may be assigned to work in a radiologically controlled area only if all of the following conditions are met:

- (1) The area must be radiologically safe for the intended operations.
- (2) The employee must be medically fit.
- (3) The employee must be properly trained.
- (4) Appropriate radiation protection procedures must be prepared.
- (5) Appropriate dosimetric, survey, surveillance and reporting procedures must be implemented.
- (6) Adequate controls and records must be established.

Guides are being prepared which will help to assure that this policy is implemented. The guides are intended to provide some consistency in the protection of NASA employees but are generalized to allow for individual differences in existing programs at the Centers.

Medical fitness is by far the most difficult requirement to express in terms of generalized guidance. The difficulty is due primarily to the lack of agreement among agencies and organizations and among their physicians. Since there is no consensus to follow, it will be necessary to make a number of decisions in this regard. Additional difficulties arise because of the dual objectives of a medical examination program-- protection of the worker's health, and protection of the employer against unwarranted claims.

Our study of this question began with an effort to find out what other Federal agencies, and what AEC contractors, are doing. The following letter was sent to several agencies and to physicians at forty AEC contractor installations:

"The subject of medical examinations for radiation workers is currently being studied at NASA with a view toward the development of the Agency's standard in this regard. From our determinations to far, there appears to be little general agreement as to the necessity and effectiveness of such examinations.

It has occurred to us that from your considerable experience you may have arrived at certain conclusions regarding the usefulness of such examinations from both the personal protection and the medico-legal viewpoints. To be more specific, it should be mentioned that we are looking at four types of examination--pre-exposure, post-overexposure, routine periodic, and termination.

A particular problem that we have with pre-exposure examinations is whether they should be conducted to establish medical fitness for employment as radiation workers or for baseline purposes only. The content of the examination apparently should be determined by this consideration. The basic question with medical fitness is whether there are any physical conditions which should prevent employees from receiving radiation exposures at the permissible occupational levels. We are very interested in your position on this question.

Subsequent examinations following very high exposures are obviously necessary for the benefit of the employee. However, for exposures greater than regulatory standards but less than levels of immediate medical concern (e.g., an acute exposure of 10 R to the whole body), it may be that the most useful purpose of the examination would be medico-legal. If this value is substantial, examinations following exposures at these levels should always be required. Knowledge of your policy in this regard would be helpful to us, and in particular we would like to have the benefit of your experience regarding the value of such examinations in the adjudication of claims.

The medical value of routine eye lens examinations for workers exposed to neutrons and other high energy particles seems to be generally accepted. Routine examinations of the hands, face, and eye lens of analytical X-ray equipment operators also appear to be necessary for medical reasons. However, the medical necessity of routine physical examinations, conducted annually or bi-annually for all radiation workers, and conducted for the purpose of verifying medical fitness to continue work in restricted areas, seems to be questionable. It may be that the forensic necessity is more readily evaluated. We would like to know your position on this problem.

The value of termination examinations appears to be almost entirely medico-legal. It appears that the recorded results of such an examination would be useful in the event of a subsequent claim. Our principal difficulty is whether such examinations should always be performed, or whether the examination should be contingent upon certain conditions (such as a former over-exposure), and if so what these conditions should be. Your comments on this problem would be appreciated.

We are aware of the time and effort involved in the preparation of a reply to a letter of this type and want to express in advance our appreciation."

Replies were received from most of the Federal agencies and from twenty-five of the AEC contractors. The replies were surprisingly comprehensive and informative, in most cases representing a considerable effort. In general, the physicians were candid in giving their personal viewpoints. Unfortunately, these varied viewpoints do not lend themselves to summarization.

The replies are unanimously favorable toward pre-placement examinations. However, the physicians differ as to whether the routine examination is sufficient for radiation workers, and as to whether the examination has actual medico-legal value. Physicians who place little emphasis on disqualifying factors seem less inclined to perform special procedures for radiation workers. Those who emphasize disqualifying factors usually do so for medico-legal reasons, and they tend to be specific with regard to special procedures. There is considerable variation in the disqualifying factors reported.

Eye examination requirements cover the complete spectrum from no specified examination at all to slit-lamp examination of the cornea, iris, and lens, with ophthalmoscope examination of the media and fundus, and fundus photographs if lesions are found. Medico-legal justification is normally given or implied for comprehensive eye examinations. Despite this reasoning, the identification of opacities or lesions is not always considered disqualifying. In these instances the purpose is to establish the presence and location prior to exposure. Some physicians feel that the legal protection provided by these comprehensive examinations is a delusion. Apparently most of the medico-legal cases have arisen from people who develop radiation-type cataracts but who have never been significantly exposed and therefore are not included in the comprehensive eye examination program. From this viewpoint, it is better to perform a careful ophthalmoscope examination for virtually everyone who enters a radiation area, with special examinations only for noted, significant lens opacities, for known over-exposure, and in cases where adequate dosimetry cannot be performed, e.g., X-ray diffraction unit operators.

Two opposing positions are held regarding medical examinations following over-exposures. Some feel that examinations should be performed following exposures that exceed permissible levels but are clinically undetectable. Others would conduct an examination only if there is reason to believe that a biological effect may be observed. In addition to medico-legal reasons, those who hold the former view believe that an examination can alleviate apprehension. Those of the latter persuasion believe that the medically useless examination needlessly creates apprehension.

Routine periodic examinations are performed at most installations, but not all. In some cases the content of the examination is more extensive for radiation workers, and in some cases the examinations are more frequent for these employees. Again, the degree of emphasis placed on disqualifying factors is influential. It is interesting to note that while one physician will perform pre-placement and periodic examinations, another will perform pre-placement and termination examinations; and a third will do all three.

A wide range of termination examination policies is evident. This examination may be required for all employees, or only for radiation workers, or only for those significantly exposed, or for employees concerned about their exposure, etc. The justification may be medico-legal, or primarily employee benefit, or for good will purposes, or to gain insight into plant problems, etc.

By far the most intriguing aspect of these replies is that each one contains at least one new and different thought. We believe that the survey has provided information that will be invaluable in the development of the NASA standards.

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**EXPERIENCES WITH PHYSICAL CONDITIONING
PROGRAMS IN MIDDLE-AGED MEN**

Benjamin Schuster, M.D., F.A.C.C. and
Edwin Stanley, M.D., Dayton, Ohio *

INTRODUCTION

The great exercise fad has swept the United States with literally thousands of juveniles, adults, and senior citizens puffing along the sidewalks, tracks, and roadways of America. The slogan "run for your life" has stimulated the minds of many with the fond expectations of weight reduction, improved physical fitness, lowering of cholesterol, and prevention of coronary heart disease.

What is the medical evidence that confirms the value of a regular exercise program? Numerous studies in universities, YMCA's, and the military have shown marked changes in the heart rate, muscular stamina, and psychological responses in individuals performing prescribed, regulated programs of physical conditioning. When sufficient regular physical activity is carried out by jogging, bicycling, swimming, walking, etc., the medically well adult can expect improvement in the body responses. Charts are available (e.g., Cooper's aerobic program) that prescribe the level of physical activity required to promote a high level of physical conditioning.

However, little or no evidence is so far available to document the long term effect of improved physical conditioning. Much has been written about the relationship of physical activity to the incidence of coronary artery disease and the possibility exists that lack of regular exercise is associated with higher frequency of heart attacks. The question, "Does regular exercise reduce the danger of heart attacks and prolong life?" still remains unanswered.

The Cox Heart Institute of Dayton, Ohio, is now in the process of studying the long-term effects of physical exercise and conditioning in the prevention and treatment of coronary heart disease. This paper deals with some aspects of the problem and points out difficulties encountered in a group of middle-aged business executives using a carefully prescribed, but non-regimented and loosely supervised conditioning program employing commonly used forms of exercise (bicycling and jogging).

* From the Cox Heart Institute, Dayton, Ohio - Supported in part by a grant from Miami-Valley Heart Chapter, American Heart Association, Dayton, Ohio

METHODS

Fifty-six middle-aged (38-60 years) white male executives (engineers, corporate vice-presidents, treasurers, etc.) of Dayton, Ohio, industrial and commercial firms were matched with 56 controls. Questionnaires had originally been sent to 200 high level business executives asking for voluntary participation in the program, either as a participant or as a control. Those individuals indicating an interest in a four to six months program of progressive aerobic exercise were then instructed as to the type of testing to be performed, the manner of exercise, i.e., on a bicycle or jogging, and the methods of recording exercise performance.

The bicycle used was a narrow-tired, 1-5/8" (60 lbs. pressure), continental style, three-speed bicycle. It has a standard saddle, handle bars, hand brake, and weighed 12 lbs. A speedometer and mileage meter were added to permit recording of mileage to control the exercise intensity. All bicycling was performed on bicycle routes or residential streets with no grade greater than 10%. A sheet for recording the number of miles ridden daily was given to each participant at the start of the program and it was to be filled out and mailed to the exercise laboratory monthly.

The subjects who selected jogging were instructed by the local YMCA as to the method of running. The men were to exercise at the running track at the local YMCA, a local high school track, or the sidewalks of their community. A form sheet similar to the bicycle group was utilized.

No attempt was made to change the habits of the participants (dietary, smoking, alcohol, etc.). Since the occupations of the participants involved traveling in some cases, they were encouraged to continue the progressive exercise program even while away from home.

TESTING TECHNIQUES

Each subject had an initial examination, including history, physical examination, blood sugar, cholesterol, and blood count. A chest X-ray, resting electrocardiogram, double Master's two-step test, and pulmonary function tests were performed. Only exercising subjects and controls who were judged essentially normal from a cardiovascular standpoint were placed in the study group. Blood cholesterol and a physical examination were repeated at the completion of six months of the program.

A submaximal exercise test was performed prior to the start of the program and was repeated at two, four, and six months for the exercising subjects and at six months for the controls. At least one hour, following a light meal, the subject wearing tennis shoes and gym shorts was brought to the exercise lab. A resting supine 12-lead standard electrocardiogram was performed and bipolar ECG electrodes (Beckman) were attached to the right scapular and left chest (V-4) positions. The subject was then seated on a Godart variable resistance bicycle ergometer, and the sitting electrocardiogram recorded on a Sanborn 500 recorder. The left brachial blood pressure was also recorded using a sphygmomanometer. Expired air was collected in 200 liter bags using low resistance valves (McKesson one-way) and rubber mouth piece. Total volume of expired air was measured using a Tissot spirometer. Oxygen concentration was determined by a Beckman E-2 electromagnetic oxygenator and carbon dioxide was determined by a Godart capnograph. Daily calibration of the meters was made from compressed gas tanks, with known concentrations of oxygen and carbon dioxide determined by micro Sholander techniques.

After a two-minute warm-up period at zero workload the subject exercised at a 300 Kgm setting for four minutes. The bipolar ECG and blood pressure were recorded at two and four minutes respectively and the expired air collected during the fourth minute of exercise. The subject then rested (on the bicycle) for four minutes and repeated the test at a 600 Kgm workload. Following another four minutes rest period, a workload of between 750-900 Kgm was selected so that the heart rate would approach or exceed 150 beats per minute. Two-and-four minute recovery heart rates and blood pressure recording were obtained with the subject sitting on the bicycle. A standard post exercise 12-lead electrocardiogram was then recorded in the supine position.

The standard and bipolar electrocardiograms were coded according to Blackburn's criteria for resting and exercise ECG's. The computation of oxygen consumption, ventilation and respiratory quotient were performed by standard techniques using a program written for the IBM 1800 computer. Oxygen pulse, pulse workload (heart rate 130 and 150) and ventilatory equivalent were calculated by standard techniques. Predicted maximum oxygen consumption was calculated from the heart rate, using Astrand's nomogram. Body surface area and calculated lean body mass were determined using height, weight, and skin caliper measurements.

The accumulated data were punched on IBM cards and statistical analysis performed on an IBM 1800 computer. A two-way analysis of variance was performed on the data for comparison of the results of pretraining, and at two, four, and six months periods. Significance of change was evaluated using the Student T test and P values.

RESULTS

There was considerable variation in the amount of exercise performed and the diligence with which the participants continued the prescribed program. The individuals were classified according to the amount of exercise performed as poor, fair, and good exercisers. (Table I). This information was derived from the log which the participant kept and turned in monthly to the exercise lab. The "good" category included the individuals who completed the required number of miles, the "fair" up to one-half of the requirement and the "poor" less than one-fourth of the program. Three men in the bicycle group and four men in the jogging group failed to turn in log sheets.

In 56 controls, only 44 were available for testing at the end of six months. Some of these men had moved out of town and others did not have the necessary interest to continue. Of 26 men who started the bicycle conditioning program, 25 completed six months and 17 are still exercising after 30 months. The one man who dropped out of the program in the first 6 months sustained a myocardial infarction. It is interesting that he is the only man in the group who actually showed deterioration in his fitness studies during the program. Of the 34 men who started on the jogging program at the YMCA, 28 were continuing at six months and 24 were still exercising at 24 months.

The comparison of the controls with the two groups of exercising men in the initial (baseline) study demonstrates several similarities. The average age of the control group was three years older (48-45) while the total body weight was identical, 81.3 Kgm. The serum cholesterol was similar (239-225) with an average caloric intake of 2450 calories with 40% fat. The resting and exercise heart rates of the controls were lower than the two groups in the baseline study, while all other parameters were quite similar. (Table II). It is of some importance to note the baseline and six months test results in the control group. All parameters are essentially unchanged indicating the stability of the physiologic variables in a group of men exercising.

The six month results in the exercising groups showed several parameters that changed in the direction expected with improvement in physical conditioning. A small decrease in systolic pressure was noted in the resting and two levels of work. The heart rate showed the greatest change (up to 14% decrease) following the exercise program. The decrease was present in the resting, peak exercise, and recovery heart rates. In general, the decrease in heart rate was greater in the bicyclers compared to the joggers. The O₂ consumption, ventilation,

and respiratory quotient parameters (Tables III and IV) did not show any trend associated with the program except for a slight decrease in variation at high work loads, i.e., 750-900 Kkm. The oxygen pulse (O_{2p}) Table V) did show an increase (probably related to the decrease in heart rate) with physical training. No change occurred in total or lean body weight and serum cholesterol.

After four months of physical conditioning in both bicycling and jogging subjects, changes in the amount of exercise performed were observed. (Table V). The maximum heart rate and recovery heart rate parameters appeared to have decreased in both the good and fair joggers, with no meaningful change occurring in poor joggers.

In the Bicycle group an apparently greater improvement occurred in the fair exercisers than in the good exercisers (Table V). This may be due to selection bias, as the seven individuals in the good group had lower heart rates and perhaps better physical conditioning at the time of the baseline study.

The two-way analysis of variance performed on these changes did not reach a significant level of confidence ($P > 0.05$) which indicates that the changes in heart rate may not have been due to the level of exercise. Therefore, while there was considerable difference between the six month tests in exercisers and controls, the results may not be considered statistically significant. All other parameters also failed to meet the two-way analysis of variance test for significance.

SUMMARY

1. An exercise program was instituted for middle aged business executives in a community setting. Both jogging and bicycling were selected as the methods of exercising.
2. The level of exercise performance varied markedly in an unsupervised program.
3. Improvement occurs in physical conditioning with a self-regulated non-supervised program:
 - a. Related to amount of activity engaged in by participants.
 - b. A rigid statistical analysis suggest the variability in individual changes is so great that significance of changes is doubtful.

4. Exercise performance in well informed and motivated executives will not, under the conditions obtained in this study, result in a very great improvement in physical conditioning. The participants separated into three groups---good, fair, and poor exercisers, depending on motivation, job demands, time available, etc.
5. A short term study will not indicate the effect of regular exercise on prevention of heart disease. No change occurred in body weight and serum cholesterol, if other measures (diet, smoking, alcohol, etc.) were not changed.

No attempt was made to study psychological changes, such as lessening of tensions, improved sleep, sense of well being, increased efficiency on the job, but nearly all of the participants in the exercise studies seemed satisfied that they had engaged in the study, and the majority are continuing in the long-range program which is now going into its second year. It is believed that the beneficial effects of exercise failed to be significant in this study as in other short term studies because the effects require a matter of years for manifestation.

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EXPERIENCE FACTORS IN PERFORMING PERIODIC
PHYSICAL EVALUATIONS

Archie A. Hoffman, M. D., Consultant

Although I had been involved with examining an asymptomatic population in the Flight Surgeon's Office since 1940, I became immersed in the problem of the Periodic Health Examination (PHE) during the period 1958-1968. In Headquarters Command, USAF, which is comprised mainly of personnel in the Washington, D.C. area, we performed a total of 10,000 to 12,000 complete physical examinations per annum. All personnel on flying status, inclusive of air controllers, parachute duty and physiological training were examined annually. Other officers were examined annually. Other enlisted men were examined on a quadrennial basis with additional examinations being done on assignment to Southeast Asia and isolated duty. About two-thirds of the enlisted men are under age 28 with only about 10,000 at age 50 and above. It should be kept in mind that at the induction centers the hypertensives, those with valvular heart disease, with muscular-skeletal defects, with gross mental and neurologic disorders, diabetics, albuminurics, those with deafness and severe visual errors, are screened out. Even so, at the Basic Military Training Center, another group is washed out within a few weeks primarily with skeletal and mental defects.

With the Examination Unit manned by trained physicians and adequate paramedical personnel, we were faced with these pressures:

- Deadlines for Southeast Asia and isolated duty separations - Reenlistments
- USAF Academy applicants
- AFROTC candidates and members
- Periodic Health Examinations

It takes an extremely well motivated physician, extra inducements or the beatings of war drums to maintain enthusiasm in working in such a unit for longer than 30 days. To overcome the tedium, we used aviation medical technicians to do required measurements, purely mechanical procedures and to record this data, thereby reserving to the physician the elements of judgment. He was also charged with health counseling.

We also instituted an Executive Health Program involving an average of 1500 senior individuals/annum. Cost analysis ranged from \$100 to several hundred per assessment. The find was minimal and extremely expensive. At age 45, proctosigmoidoscopic examination was added to the annual examination. Beginning at age 50, we added special X-ray diagnostic procedures on five year cycle allowing one per/annum: gastro-intestinal series, gallbladder series, barium enema and urogram. By 1967, it was felt that these special studies were non-productive. G.I. series disclosed

peptic ulcer deformity in 19%, known prior to the procedure; hiatus hernia 11.4% of which 6.3% was known before; barium enemata disclosed diverticuli of the colon in 2.5% with half known before; cholecystogram showed silent gallstones in 3.8%; intravenous pyelography had no pay off.

In 1957 we did sugar loading on 3000 successive examinees and found only two mild middle-age diabetics. In 1960 we began to do routine testing of intraocular tension with the Schiötz tonometer at time of periodic examination beginning at age 40. We did find a few with preglaucoma but caused more to suffer with a chemical burn of the eye.

An analysis for our 1964 experience is shown on the following charts.

CHART #1
Waivers Granted - 1964
Common Conditions

	Flying Personnel (3565)	Non-Flying Officers (5914)
Abnormal ECG	5	3
Hypertension	6	8
Hiatal Hernia	4 (#3)	5
Carcinoma of skin	5	8
Presbyopia	115 (49%)	4
Refractive error	3	8
Distant vision	83 (35%)	-
Exophoria	6	-
Preglaucoma	5	-
Diabetes mellitus	-	8
Duodenal ulcer	2*	1

*detected at clinic

CHART #2
Abnormal ECG - 1964

<u>Flying</u>		
Non-specific T wave change, normal variant	age 45	DIF
Non-specific T wave change, labile	age 45	DIF
Non-specific T wave change, labile	age 45	DIF
Silent anteroseptal infarction	age 43	DNIF
RBBB, complete	age 26	DIF (airman)
<u>Non-Flying</u>		
Non-specific T wave change, normal variant	age 43	Duty
PVCs & ST-T wave change	age 52	Retention
Probably anterior septal infarction	age 40	Retention

CHART #3
HYPERTENSION

1. Dg of Essential Hypertension, mild, made on 6 of rated group (3565).
DP 100 mm Hg. Ages: 39, 42, 44, 46, 46, 48. All on status.
2. Dg likewise made in 8 of non-flying officer group (5914).
Ages: 42, 44, 45, 47, 47, 49, 52, 52. All on duty.

DIABETES MELLITUS

1. Found in 8 non-flying officers (5914).
6 at times of physical examination
2 at sick call
2. All are mild and controlled by diet.
3. Two were overweight.
4. Ages: 39, 46, 46, 46, 48, 49, 50, 53.

My basic dissatisfaction with the PHE methodology came to a head in 1964 triggered after reviewing an article in the December 1964 issue of the Annals of Internal Medicine on the evaluation of the PHE by participating groups. This paper showed that coronary artery disease was recognized before death in only 58% and malignant disease in 43%. I do not mean to infer that we did not find pathology. We found all kinds at the clinic. The average military member is reluctant to describe signs and symptoms at the time of his periodic examination. Independently, Gordon S. Siegel, M.D. (Ref. #1) arrived at a similar conclusion, namely, that he challenged the PHE premise of discovering disease (or disease propensity) in the asymptomatic stage permitting favorable intervention. I agree with him that the premise of the PHE still has to be proved. Dr. Siegel urges early sickness consultation (ESC), coupled with the use of periodic selected disease screening procedures, as being effective and a more practical public health measure.

In 1967, I recommended the following to the Air Force Surgeon General:

(1) At time of examination, a meticulously documented medical history to include a medical record review and an inventory of systems.

(2) At time of retirement for length of service or medical retirement, the following tests to be incorporated in the Standard Form 88:

(a) Blood urea nitrogen or creatinine.
 (b) A two-hour postprandial blood sugar after fasting for three days before with a daily diet containing at least 300 gms of carbohydrate.

(c) A VDRL or other test for syphilis (STS).

(3) Other procedures recommended for consideration but not mandatory:

(a) A proctosigmoidoscopic examination for asymptomatic examinees at age 44 on a triennial basis and converting to a biennial basis at age 50.

(b) One barium enema during the fifth decade of life.

(c) Complementing PA of chest radiograph with a left lateral view.

I participated in a special committee to establish for the Air Force a program for periodic medical examination with frequency and scope. In general, most of our study was accepted for implementation in August 1968.

<u>Category</u>	<u>Frequency</u>	<u>Special Studies</u>
Pilots, Navigators, Flight Mechanics, Flight Engineers, Boom Operators, Gunners, Loadmasters	Annually	Baseline ECG on record. ECG annually at 35 yrs and thereafter. Tonometry at age 39. If normal, repeat every second year. Rectal, age 39 and annually.
Flight Surgeons Flight Medical Officers Flight Nurses, Medical Techs and all Noncrew Members	Biennial beginning at age 19 thru 59; annually above 60.	Baseline ECG on record. ECG at age 35 yrs and each exam thereafter. Tonometry and rectal exam at 39 yrs and each exam thereafter.
Other Officers and Airmen	27, 31, 35, 39, 42, 45, 48, 50, 42, 54, 56, 58, 60 and	Baseline ECG for 35th birthday, if not already in record. ECG, tonometry and rectal exam at time of periodic evaluation beginning at age 39.
Female Officers	Same as above group except annual limited exam	Same as above. Limited scope to include pelvic and breast exams and Pap smear.
Air Controllers Weapons Controllers Physiological Trng Pers Parachute Duty Pers Missile Launch Crew	Annual	Baseline ECG for 35th birthday. ECG annually, age 39 and over. Rectal exam annually, age 39 and over. Tonometry at age 39. If normal, repeat every 3rd yr.

This schema will probably result in an overall reduction of examinations and can probably be further reduced by the universal usage of the FULHES system. It is hoped that the flight surgeon will have more time to spend with his charges exclusive of the business of performing examinations.

The Air Force seems to be heading in the right direction of multiple screening and providing maximum coverage in sensitive areas. In the civilian community, much of the problem could be resolved if a thorough baseline assessment were done in the late teens or in the twenties age group. This having been done, a system of multiple screening could be established in relation to the age of the group. As an example, I propose that we look at the following areas in an asymptomatic population:

Systems

Periodicity

Eyes: vision and intraocular tension	Start at age 40; repeat every 5 years.
Allergies: nose, sinuses, lungs, eyes, skin	Check once at age 30.
Thyroid	Age 30; recheck every 5 years.
Cardiovascular	Check at age 30 with baseline ECG. Recheck every 5 years. Consider stress test.
Pulmonary	Check at age 30. Ventilatory study. Repeat every 5 years.
Metabolic	Check for gout at age 30; repeat every 10 years. Check for diabetes mellitus at age 40; repeat every 5 years.
Rectum	Rectal examination at age 40. Repeat every 5 years.
Genitourinary	Check at age 40. Repeat every 5 years.
Dental	Periodontal survey at age 35 and repeat every 5 years.
(Female-breasts & pelvic organs)	Annal (include hemoglobin)
Blood	BUN, hematocrit, cholesterol, etc. Age 30 and every 5 years.

This plan would theoretically locate potential disorders. In regard to the eyes, presbyopia would be corrected. Intraocular tension should be measured with the applanation tonometer by an ophthalmologist or a trained technician. This equipment is expensive. The fundi should be visualized.

Allergy in one form or another involves 5% to 20% of the population. Prevention and treatment are available.

Thyroid disorder is concerned with goiter, thyroiditis and cancer detection together with underfunction and overfunction.

The cardiovascular system deals with hypertension, valvular heart disease and atherosclerosis. It has been demonstrated that a regular exercise program (Ref. #2) with the individual's limitation improves the blood lipid pattern. Exercise and diet have a favorable effect on the arterial tree.

Pulmonary scrutiny looks for infection, emphysema, bronchitis and asthma.

Metabolic factors may indicate middle-age diabetes mellitus, usually controlled by weight loss, and gout controlled by allopurinol. In ages between 55-74, annual rates of diabetes for males ranges between 100 and 125/100,000 and for female between 160 and 200/100,000. Frequency of hyperuricemia involves 1 to 2% of the general population. Gouty arthritis involves about 1% of the U. S. population and contributes to 4-5% of the arthritic population.

Rectal examination should be expanded to proctosigmoidoscopic technic at age 45 and one barium enema in the fifth decade. In the 1960 incidence of cancer of the colon/100,000 for men was 29.9, for women 34.2; incidence of cancer of the rectum for men was 20.2, for women 14.4. To state it another way, there is a tenfold increase of carcinoma of the colon and rectum between ages of 45 and 65.

Genitourinary examination is concerned mainly with urinalysis and palpation of the prostate as starting points. Carcinoma of prostate incidence is 42/100,000. The incidence of urinary tract infection and prostatism has to be clarified.

In the dental area, control of periodontal disease is required for adequate nutrition and elimination of constitutional effects. The incidence in the group over age 30 is well over 50%.

In regard to the female, incidence of the following cancers (1960) / 100,000 are as follows: breast - 72.6, uterine cervix - 28.7, body of uterus - 16.

At this point, I would like to make reference to an EDP system of acquiring a medical history. This can be modified and is available to analysis. The most important part of a screening procedure, PHE or a clinic visit or consultation is the medical history. In this area, the new Labey Clinic Automated Medical History Questionnaire is an excellent example of comprehensive coverage and presentation of a functional printout to the physician. I believe that this technic can be used on any group being surveyed.

SUMMARY

My paper presents my feeling of the lack of scientific basis to the so-called PHE inclusive of the Executive Health Program. This latter program can well represent a management tool of the company involved in addition to being a status symbol. I have proposed consideration to a multiphasic screening technic in conjunction with an automated history questionnaire. The solution will be found by those concerned with preventive medicine - occupational medicine methodology. The need to collate early sickness consultation or clinic visit with screening technic is necessary.

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Stability of Human Sera Collected for Clinical Chemistry Determinations

1173-17052

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Two vital steps in any chemical analysis of biological fluids are the collection of the specimen from the patient and its preservation from the time of collection until the actual examination is begun. There are many potential sources of error, beginning with the securing of the specimen and not ending until the results are placed in the patient's record. It is not within the scope of this report to consider all facets of potential error. The work of Caraway (1) and Wirth and Thompson (2) consider these in some detail, including the effect of medications on clinical chemical laboratory results.

Since laboratory centralization is coming more and more into being in this country, the shipping of specimens to central laboratories has become more frequent and extensive each year. In spite of this trend, it is very difficult to obtain documented information on the stability of specimens under the conditions of transport by mail and other means. There is a considerable variance in the literature on the stability of different substances in blood serum. For example, Mosley and Goodwin (3) found SGPT was very unstable at -20°C . but was relatively stable at low temperature (-50°C .) up to 98 days. Juul (4), on the other hand states that SGPT is stable at -20°C . for 8 days. In our laboratory it was found that SGPT could not be preserved at all in a -20°C . freezer. Tests were not made in our laboratory at -50°C . There are numerous other similar conflicts. Much of the stability testing has been done for periods of 10 days or less, which is satisfactory in most situations if specimens to be mailed or transported are handled with reasonable promptness.

Henry (5) annotates most of his procedures with a note as to the relative stability of the substance to be tested under the usual laboratory conditions of room temperature (25°C .), refrigerator (4°C .) and freezing (-20°C .). Hagebusch (6) discusses some of the practical problems arising in a central laboratory in the St. Louis area.

In the case of enzymes much of the testing has been done on sera containing normal levels of the specific enzyme with little attention to carefully controlled studies on abnormal levels (7). Information on the stability of some enzymes at room temperature is lacking.

The following chart represents an attempt at listing the stability of various substances under the conditions that exist in the routine clinical chemistry laboratory. Some of the times are at variance with those given in the various publications on the subject. They do represent an attempt to arrive at practical limits and incorporate data obtained in our

laboratory from a continuing study of the problem of specimen stability. Reliable published data is lacking on the effect of freezing at -20°C . in many instances. It is likely that some of the room temperature times and refrigerator stability times may be longer or shorter than shown based on individual or unpublished experience.

A perusal of these data indicate that for practical purposes refrigeration of serum specimens after collection will be satisfactory, unless the specimen is frozen. The time for handling a specimen to be analyzed for bilirubin is very short; a maximum of 4 days with care to avoid exposure to light being essential for reliable results, if not frozen. Glutamic pyruvate transaminase (SGPT) is very unstable and cannot be shipped unless the shipping time is carefully controlled and is less than two days under refrigeration. Glucose will decrease if sample left at room temperature. As noted below glycolysis can be reduced with a sodium fluoride thymol mixture.

Shipping is best accomplished by using insulated containers with cooling provided by commercially available cans or plastic bags than can be frozen. In a properly insulated container they will maintain a low enough temperature to preserve the specimen en route. Obviously, sera can be shipped without refrigeration for those tests that show a good stability at room temperature, i.e., a room temperature (25°C .) stability for 7 days or more. However, in shipping, particularly during the summer months, temperatures may exceed 50°C . No good information is available on the effect of such temperatures. Hagebusch (6) considers this and found urea nitrogen, creatinine, uric acid, protein and SGOT little affected by excessive heat in shipping. Glucose, albumin, globulin, bilirubin, alkaline phosphatase and cholesterol showed varying degrees of instability.

The use of "preservatives" for maintaining the stability of specimens en route to a central laboratory is used in some instances. The literature and standard textbooks that were consulted were rather mute on this point. 11 mg. of a 10:1 mixture of finely powdered sodium fluoride and thymol per ml. of blood will help prevent glycolysis. Doe, Mellinger and Seal (8) used a citrate buffer at pH 6.2 in serum to be tested for alkaline phosphatase and found this would lessen the decline that normally occurs at room temperature.

It appears that the whole area of proper specimen preservation needs more careful investigation with both normal and especially serum containing abnormal elements. The relative stability of most specimens handled in the ordinary hospital clinical laboratory present no particular problems. However, with more and more utilization of central facilities more specific information on specimen stability is needed. It is true a specimen can be shipped and the determination made for whatever substances that are of concern to the physician. However, are the results

always completely reliable? In the majority of instances they appear to be acceptable. All of the answers to this problem are not complete at this time and must await further and more systematic study.

173-17053

Psychosocial Factors in Coronary Heart Disease

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Despite the seeming complexity and size of modern organizations we still find that single individuals often exercise critical influence in terms of the unique expertise and understanding they develop in their particular roles. It takes months, even years before a top administrator or a scientist fully begins to understand all of the subtle, yet important nuances which surround his work. When such a valuable person, a human asset, dies before retirement, the organization suffers a valuable loss (one which to this day we are unable to measure in dollars or in accomplishment of the mission). No amount of financial insurance can reimburse an organization against such loss, particularly under conditions where there are deadlines to be met and little time to train replacements. Under such conditions, and they appear to be more frequent in the fast-moving modern world, the best form of insurance is to prevent premature death among the members of the organization. Coronary heart disease is one of the most prevalent forms of pre-retirement death in modern organizations. The aim of our current research is to contribute to such insurance by identifying risk factors in coronary heart disease which will be useful in preventive medicine.

Over the past twenty years, evidence has mounted suggesting that the incidence of heart disease varies from one broadly-defined social condition to another (socio-economic class, blue vs. white collar, rural vs. urban) and from one occupation to another. If we ever hope to be able to prevent or reduce the incidence of coronary heart disease within an organization, however, we must turn our attention to attributes of the environments which are more specific than social class or occupation. We cannot prevent heart disease by eliminating those social classes or occupations which have a high risk. However, if we can identify those particular job stresses which produce the risk, then we may be able to reduce these stresses and thus control the disease.

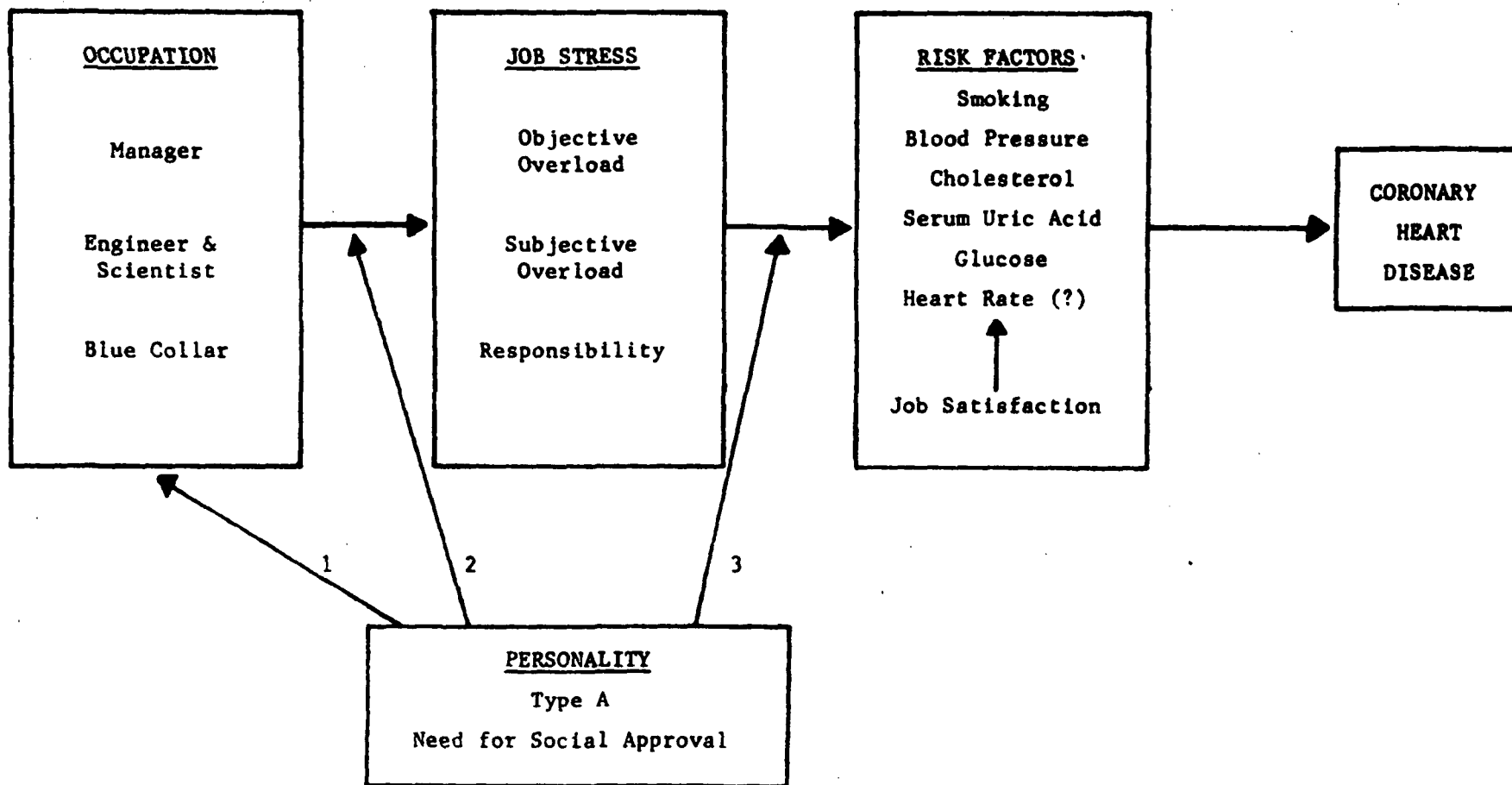
What is called for, then, is a more sophisticated and refined look at the job environment and all of the forces that act upon the individual which may lead to certain breakdowns in his natural functions--and perhaps to illness and death.

This report of our research for NASA presents some of the more specific psychosocial factors related to heart disease. Our basic approach in carrying out this research is depicted in Diagram A on the following page. The horizontal arrows represent hypothesized causal relations. We assume that coronary heart disease, represented in the box on the right of the diagram, is caused by several factors which act upon and influence one another in a variety of ways.

We know from a wealth of medical research that there are certain well-known risk factors, closely tied in with the physiology of the person, which increase his chances of having heart disease. These are represented in the second panel from the right. Smoking, blood pressure, cholesterol, serum uric acid, and glucose have all been suggested as risk factors in heart disease. We have included heart rate, not because it is a well-known risk factor, but because it does show changes under stress. We also include job satisfaction as a risk factor here. Its inclusion is based upon our new findings which we shall discuss shortly.

Further to the left in Diagram A we find the next panel presenting job stresses. We are hypothesizing in this model that certain types of job stresses cause certain changes in the risk factors. Thus, under stress a person may smoke more and his blood pressure and cholesterol may go up. In talking about job stress, we must differentiate between objective and subjective stress. Objective overload is stress which actually occurs in the person's external

Diagram A: How could we explain the occupational differences in CHD?



environment. For example, if a man receives too many phone calls and office visits this may constitute one sort of objective overload. Subjective overload, is a stress which exists solely within the individual--it is how much work load he feels he has, how much of a burden or pressure he believes he is under. Our previous research at NASA has shown that it is important to distinguish between these two types of overload. For, although subjective and objective overload are somewhat correlated (that is, people do feel overloaded when they actually have more phone calls than is normal), these two types of overload may have different effects on the risk factors listed in the adjacent panel.

As an example, in a study of twenty-two white collar men at NASA we found that pulse rate was primarily a function of subjective overload while cholesterol level was a function of both subjective and objective overload. To the medical practitioner this means that one must have an understanding of not only the actual work load of the patient, but of his subjective feelings about the work load as well.

Another type of stress which we are considering here is responsibility. Wardwell and Bahnson (1964) have suggested that it isn't mere responsibility which is the crucial stress but responsibility for other individuals--the responsibility one has for the welfare and actions of other human beings. On the other hand, responsibility for non-person-oriented aspects of work such as for budget, equipment, and projects should not increase coronary risk according to the responsibility hypothesis.

Occupation is another major variable included in our model. As we have already noted, there have been many studies published in medical journals which indicate that the incidence of heart disease tends to vary by occupation (see Marks, 1967 for an excellent review of the literature in this area). Our

reason for including occupation in the far left panel of Diagram A is to indicate that different occupations may be characterized by different types of stresses. The job of administrator may have one type of responsibility while the job of engineer or scientist may have another type of responsibility. Similarly, we would expect that blue collar jobs also have their unique forms of occupational stress. Each of these different forms of job stress might affect the risk factors in a somewhat different manner. With this type of differentiation we can begin to more specifically explain global differences between occupational groups in incidence of coronary heart disease.

On the following page, Table 1 presents some data which reveal the nature of such occupational differences and their relationship to cardiovascular disease at NASA. These data were gathered from three NASA installations by Jean Mockbee, a statistician from the Occupational Medicine Division at NASA Headquarters.

Looking at the 35-44 year old age group we see that the trade, craft, and technician employees, who are primarily blue collar, have the same prevalence of cardiovascular disease as do managers (2.9%). Further more, their rate of disease is almost six times as high as it is for the engineers and scientists whose prevalence is only .5%. The engineers and scientists have a significantly lower rate of cardiovascular disease. Turning to the 45-54 year old age group, we again see that the engineers and scientists have the lowest prevalence (2.2%) when compared with the managers (5.7%) and the blue collar group of trades employees (3.2%). Mrs. Mockbee informs us that when the data are broken down into five-year rather than ten-year intervals, the findings remain essentially unchanged.

TABLE 1

Occupational Differences in Disease at Three NASA Installations Combined

Prevalence of Disease	Age 35-44			Age 45-54		
	Trade, Craft, Tech.	Manager	Engineer, Scientist	Trade, Craft, Tech.	Manager	Engineer, Scientist
Size of Sample	174.0	272.0	598.0	219.0	350.0	537.0
% with Cardiovascular Disease	2.9	2.9	0.5	3.2	5.7	2.2
	n.s.		P=.01	n.s.		P=.02
	P=.02			n.s.		
% with Hypertension	10.3	8.8	7.9	14.2	13.1	12.7
	n.s.		n.s.	n.s.		n.s.
	n.s.			n.s.		

Table 1 also presents the prevalence of hypertension for each of these three occupational groups. While the differences between the groups is non-significant, it is interesting to note the trend in both age ranges. The trade, craft, and technician group has the highest prevalence of hypertension (10.3, 14.2), followed by the managers (8.8, 13.1), with the scientists and engineers being lowest (7.9, 12.7).

Now let's turn to another panel in Diagram A, the one at the bottom which refers to the individual's personality. Over the past 15 years a number of studies have been published which suggest that persons with coronary heart disease tend to differ in disposition and temperament from persons who do not have coronary heart disease. These studies have led medical researchers and psychologists to wonder whether or not such personality differences also existed in these individuals prior to the onset of myocardial infarctions and other overt manifestations of coronary heart disease. Perhaps there is a coronary-prone personality.

The most extensive and well-known studies of the coronary-prone personality to date have been carried out by Drs. Friedman, Rosenman, and their colleagues. As part of the Western Collaborative Group Studies they have shown that one can predict coronary heart disease on the basis of the Type A behavior pattern. The Type A personality (as contrasted to Type B) is characterized as hard-driving, ambitious, having a sense of time urgency, upwardly mobile, engaging in multiple activities, being somewhat impatient, being somewhat aggressive or hostile, and tending to prefer job pressure and deadlines.

Friedman, Rosenman et al. have shown that the Type A personality also tends to have elevated serum cholesterol levels, elevated triglycerides and beta-lipoproteins, decreased blood clotting time, elevated daytime excretion of norepinephrine, and capillary ischemia in conjunctival tissue. Such a

wealth of findings makes it hard to ignore Type A as a relevant syndrome.¹

Another personality variable of interest is the need for social approval. Traditionally, measures of this need have been included in psychological research in order to detect the tendency of a person to bias his response to a questionnaire by giving only socially desirable answers.

While we include the measure here for the same reasons, we also have some additional motives. First, we expect that persons high on need for social approval may experience more strain during deadlines and under heavy job pressure. Under such pressures they may feel that the opportunities for them to fail at their work are greater. Furthermore these persons high on need for social approval would feel doubly threatened by failure since it would mean to them that their superiors, colleagues, and subordinates might withhold the social approval and esteem they desire so much. Thus, our second use for this measure is as an indicator of an important need which influences the person's reactions to his social environment.

Another reason for including the measure has derived from some striking findings which suggest that (a) job stress and risk factors correlate with one another quite differently for persons who are high versus persons who are low on the need for social approval, and (b) physiological risk factors correlate with one another quite differently for persons who are high versus persons who are low on the need for social approval. As an example of the latter case, day norepinephrine and day epinephrine were correlated with one another in two groups of employed blue collar men from a company in Michigan. One group of men was high on the need for social approval (as measured by the Crowne-Marlowe scale) while the other group of men was low on the need for social approval.

¹The reader is referred to the appendix for a selected bibliography covering this and related studies of risk factors in coronary heart disease.

The correlation between norepinephrine and epinephrine for the group high in need for social approval was $-.22$ but the correlation between norepinephrine and epinephrine for the group low in this need was $+.32$. Thus, there is a positive relation in one group and an inverse relation in the other group, and the difference between these two groups is statistically significant. At present, we can make no clear interpretation of what these differences mean, but they certainly are striking and demand further attention.

Referring to Diagram A once more, you will note that we have suggested several channels by which personality variables could lead to coronary heart disease. First of all, on the far left we note arrow Number 1 from personality to occupation. Personality may influence heart disease via occupational choice. For example, the coronary personality may be more likely to seek out the high risk administrative job rather than the job of engineer or scientist. And, perhaps, the coronary personality who finds himself in an engineering job takes steps to move into a more administrative job.

Another channel through which personality may have its effect is in mediating the relationship between one's occupation and the stress one experiences in that occupation. This effect is represented by arrow Number 2. To give an illustration, a manager when objectively overloaded may be more likely to experience subjective overload because he is a Type A personality. Similarly, Type A scientists may be more likely to experience subjective overload than Type B scientists when objectively overloaded.

A third channel by which personality might have some effect on coronary heart disease is represented by arrow Number 3. While job stress may cause changes in risk factors such as cholesterol and number of cigarettes smoked, such changes are perhaps more likely to occur if the person is Type A rather than Type B. Overall we have a picture of personality as a variable that effects

many levels in our hypothesized chain of events leading to coronary heart disease.

For the physician interested in heart disease prevention, one implication of the already available research on heart disease is that it may be just as important to find out about the personality of the individual as it is to find out about his work, how he views his work, and his blood pressure, cholesterol, and glucose levels. Knowledge of the person's standing on all of the variables may allow the physician (or the personnel officer of an organization) to provide additional help and counseling to the person trying to make decisions about future steps in his career development (e.g., should he continue as a manager, or should he change jobs).

If we look back on the more conventional approaches to studying heart disease we find that when one combines information about all the physiological variables plus the Personality Type A, only about twenty percent of the variance in coronary heart disease is accounted for. Eighty percent of variance is still unexplained. Recently, however, we have discovered some new findings relating job satisfaction to coronary heart disease which may account for some of the unexplained variance.

As part of a dissertation carried out by Dr. Stephen Sales, subjects were experimentally subjected to conditions of overload and underload. Pre-experimental and post-experimental blood samples were taken and analyzed for serum cholesterol. One of the findings of the study was that people most dissatisfied with the task showed the highest increases in cholesterol. This suggested that job satisfaction might be related to coronary heart disease.

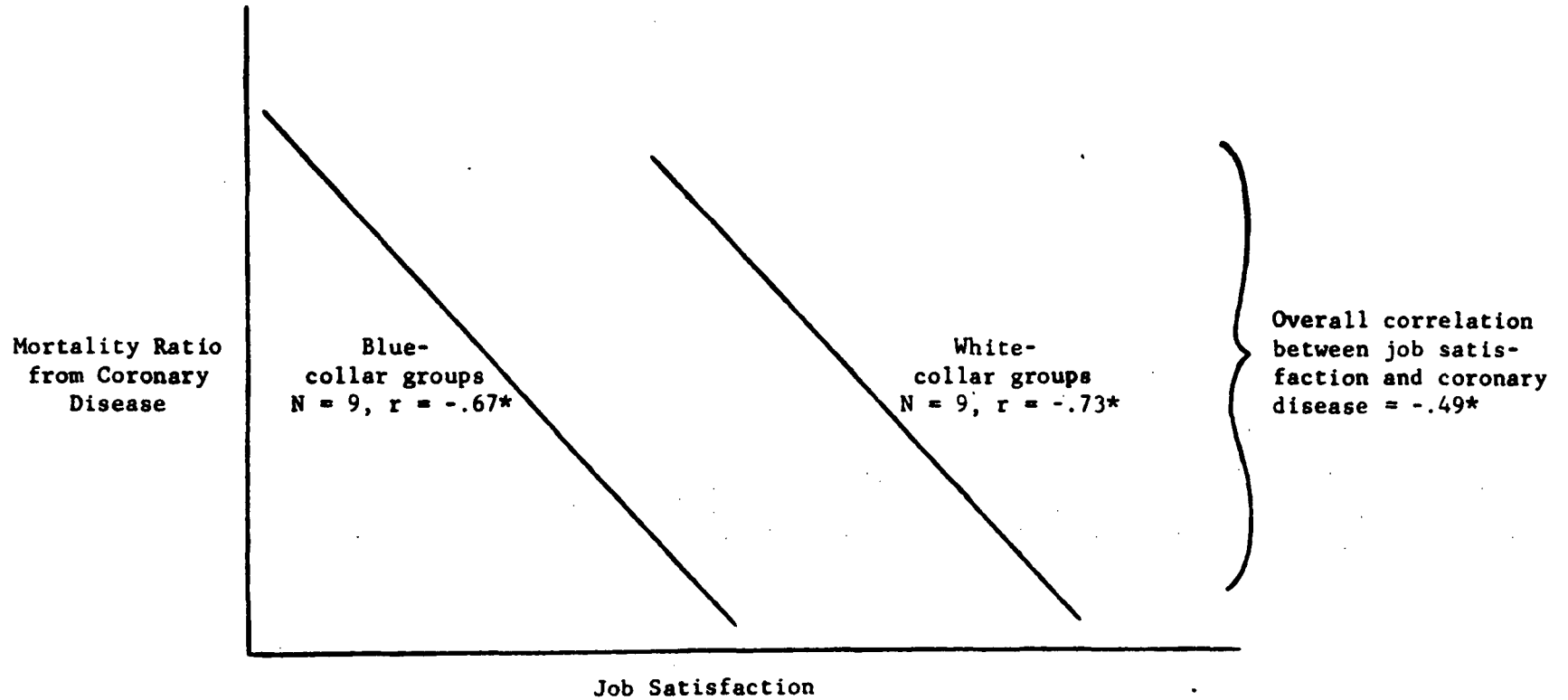
Support for this relationship between job satisfaction and coronary heart disease was obtained by comparing these two variables across eighteen occupational groups. For each occupation we had a mean job satisfaction score derived

from previous studies of job satisfaction in these occupations. We also had for each of these occupations the standard mortality ratio of coronary heart disease. Heart disease was defined as rubric 4200 of the International Classification of Diseases. The latter figures came from Public Health Service statistics. The findings are illustrated in Figure 1 on page 12.

These findings show that job satisfaction and coronary heart disease are correlated - .49 across eighteen occupational groups. Furthermore, the relationship is higher and in the same direction for both the nine blue collar groups and the nine white collar groups (note that the blue collar groups tend to be less satisfied with their jobs, suggesting that their rate of heart disease is higher). Of course, these correlations are based on aggregate statistics and are presumably larger than the parallel correlations for individuals might be.

Some additional research, using the same heart disease data, has been carried out by James House from the University of Michigan. His findings suggest that the type of motivation one has for working may be related to the risk of developing coronary heart disease. These latter findings are based on nine occupational groups and are illustrated in Figure 2 on page 13. The data show that the more the members of an occupational group are motivated to work for extrinsic rewards, such as for pay and prestige, the higher is that group's mortality ratio for coronary heart disease ($r = .63$). This relationship between extrinsic motivation and coronary heart disease rate is represented by the solid line in the figure. Intrinsic motivation, however, is inversely related to coronary heart disease. The higher the motivation to work for intrinsic rewards,

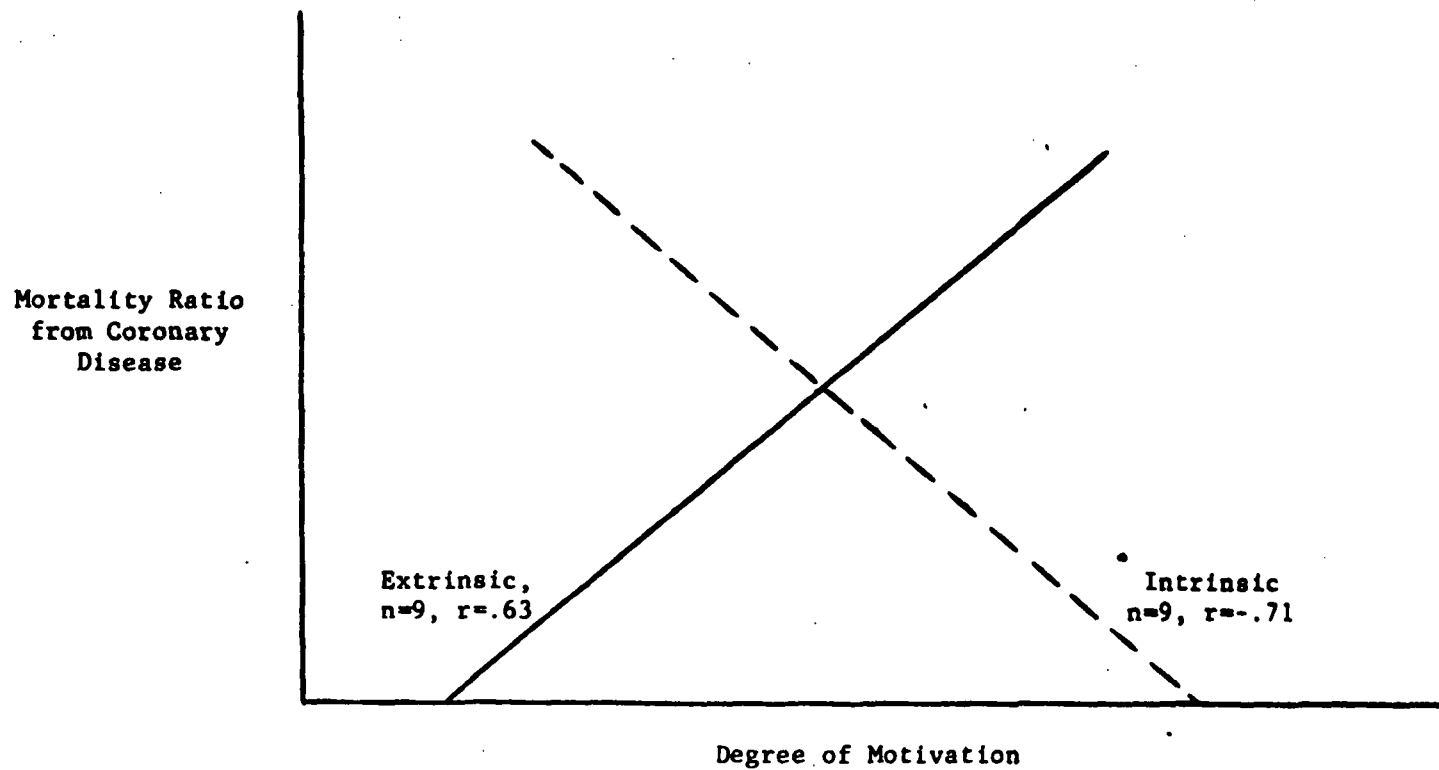
Figure 1: Relationship between job satisfaction and rates of coronary deaths (Rubric 420.0) in eighteen groups of employed men.



* p < .05

1

Figure 2: Relationship between motivation and rates of coronary deaths in nine groups of employed men.



such as for the enjoyment one gets out of the work itself, the lower the standard mortality ratio for coronary heart disease ($r = -.71$). These findings are impressive in the sense that they account for roughly thirty-six to forty-nine percent of the variance in mortality ratios. They are especially relevant to occupational medicine since the findings link motives to work with coronary heart disease.²

Now let us turn to our current project at Goddard Space Flight Center. The main purpose of this project is to explain the fact, already presented in Table 1, that managers have higher rates of cardiovascular disease than do engineers and scientists. Our general strategy will be to describe the research methods used in our most recent studies and then present the results. Finally, we shall discuss some implications of our findings for preventive medical programs.

Method

Sample

Three occupational groups of male employees from Goddard Space Flight Center--administrators, engineers, and scientists--were selected for the study. A person was initially defined as being a member of one of these three groups according to his job title in the personnel rosters of Goddard.

Next, administrators and engineers were each divided up into two additional groups. These groups were as follows:

- a) Administrators in administrative environments
- b) Administrators in engineering environments

²We are currently carrying out studies of the relationships of extrinsic and intrinsic satisfaction to coronary heart disease. The findings are similar to those for extrinsic and intrinsic motivation although it appears that there are slightly different relationships between these satisfactions and heart disease for blue collar as compared to white collar workers.

c) Engineers in engineering environments

d) Engineers in administrative environments

This breakdown was made in order to study potential fit and misfit between a person's job and the person's job environment. Where the job was similar to the job environment, as in (a) and (c) above, we said that a potential fit might be present. Where the job was different from the job environment, as in (b) and (d) above, we said that potential misfit might be present. We would then see whether the potential fit groups would report lower job stress and lower levels of cholesterol and other coronary heart disease risk factors than the potential misfit groups.

Since we formed these subgroups before actually determining the work environment of the person, we used the following definition of job environment. We defined an administrative environment as that environment where, according to the personnel records of Goddard, there existed the highest ratio of administrators to engineers using the division as the unit of environment. Likewise, we defined the engineering environment as the environment where there existed the highest ratio of engineers to administrators.

While we could find no scientists working in either administrative or engineering environments, we included the scientists in the study because of their NASA record of low rates of coronary heart disease, smoking, obesity, job absence, and other potential risk factors in heart disease.

Thus, we ended up with five groups for study: two groups of administrators, two groups of engineers, and the scientists. Our next step was to randomly sample out seventy men in each of the five groups to form a pool of potential volunteers for the study. Letters were then sent out to these 350 men informing them of the study and indicating that our laboratory assistant from The University of Michigan would probably be contacting them to see if they wished to participate.

Our assistant, a young attractive female in her early twenties, then visited 285 of these men in their offices asking them if they would be willing to participate in the study which required a blood sample of them, measures of blood pressure and pulse rate, and the filling out of a lengthy questionnaire. If the person agreed to volunteer, two readings of diastolic and systolic blood pressure and two readings of pulse rate were obtained. Then 30 cc.'s of blood were drawn. The volunteer was then handed the questionnaire and told to complete it as quickly as possible and return it to The University of Michigan by mail in the enclosed stamped, pre-addressed envelope. Eighty-nine percent of those contacted agreed to participate in the study. The average age of the men who participated was forty-years old with two-thirds of the group falling between thirty-four and forty-seven years of age. Eighty-three percent of those who volunteered returned the questionnaire. Thus, we have physiological data on 253 men and questionnaire data on 211 of those volunteers.

An option for all volunteers was to further participate by having their secretaries keep a tally of their phone calls, office visits, and meetings. This would be hopefully continued on an hourly basis for three days. Our preliminary interviews and pretests at Goddard had led us to believe that while many employees did not have their own secretaries, there was a possibility that some volunteers who did have such resources would use them in our study. Twenty-five men did agree to have such tallies taken. These men come almost exclusively from the subgroup of administrators in administration. We shall have more to say about them later.

The blood that was drawn in each volunteer's office was immediately spun to serum and frozen for subsequent shipment to The University of Michigan's Institute for Social Research. There, it was thawed and a number of analyses were carried out (cholesterol, serum uric acid, casual glucose, etc.) in a

modern laboratory using automated and highly controlled analysis equipment such as the Auto-Analyzer.

The questionnaires were then coded, and all data were transferred to magnetic tape for analyses on the computer facilities of the Institute. We shall now turn to some of the results of these analyses.

Results

The findings that will now be reported should be considered preliminary because our analyses are not yet completed. First, we shall present results which bear on previous NASA findings relating overload to physiological measures of stress. Then, we shall present some of our preliminary work on personality variables which may relate to coronary heart disease. Finally, we shall consider some of the data which relate to differences between administrators, scientists, and engineers in the current study.

As already noted, in our earlier study of twenty-two men at NASA Headquarters, we found that objective work load as measured by the number of phone calls and office visits a person had per hour was positively correlated with subjective quantitative work load ($r = .64$). We then went on to relate these measures of objective and subjective work load to our physiological variables, pulse rate and serum cholesterol level. Pulse rate and cholesterol level were unrelated. We found that pulse rate was primarily related to subjective quantitative overload rather than to objective work load ($r = .68$). We further found that cholesterol was related to both objective and subjective work load ($r = .43$ and $r = .41$, respectively). In the current study we have measures of these same variables.

Objective quantitative overload has been measured in a similar way as in our earlier study. We have determined for each of the twenty-five persons

on whom we have work tallies, the number of phone calls, office visits, and meetings they had per hour. Unlike the previous study, we find no correlation between this measure of objective work load and our same measure of subjective work load ($r = .02$, n.s.). This finding suggests that perhaps one's subjective impression regarding work load is more independent of the actual amount of work load than we had previously thought. We must, however, use caution in interpreting this finding since there are other measures of objective and subjective work load which do relate to one another. We shall discuss these measures shortly.

In the present study we also find that pulse rate does not correlate with objective or subjective quantitative work load although it was expected to do so ($r = .17$, n.s.; and $r = .04$, n.s., respectively). Serum cholesterol level also fails to correlate with these objective and subjective measures of work load ($r = -.30$, n.s.; and $r = .01$, n.s., respectively). Pulse rate and cholesterol are unrelated as in our previous study ($r = .14$, n.s.).

This failure to replicate our previous findings leads us to believe that the analyses may not have uncovered certain moderator variables which are important in distinguishing between the characteristics of the earlier sample from NASA Headquarters and the present sample of men from Goddard. For one thing, we may have a serious sampling problem regarding our measure of objective work load. In the Headquarters study, ninety-six percent of the men contacted agreed to have a tally made of their work. In this study less than ten percent contacted agreed. Thus, the data relating to objective overload measures should be treated with caution.

Second, our method of obtaining pulse rate in these two studies has been markedly different. In the study of the twenty-two Headquarters men, pulse rate was based on averages taken over three-hour periods. In the present study,

thirty second samples were taken two times within a minute or so of one another as an estimate of pulse rate. Since pulse rate is highly labile, it is conceivable that we were measuring some reaction to the test situation rather than some sample of pulse rate on the job. This suggests that we may have to return, in future studies, to the more careful measuring of pulse using our telemetry equipment.

At present we are still exploring some hypotheses about the failure of cholesterol to relate to our overload measures. These hypotheses include possibilities that seasonal variation may serve to attenuate certain relationships between cholesterol and subjective and objective quantitative work load. We have data from Goddard health examinations which show striking changes in cholesterol over the twelve months of the year with peaks in cholesterol value during November through January and troughs in March through July. The difference between peaks and troughs was 42 mg./100 ml. The present study was carried out in April and May. The previous study was carried out in June through August.

While our findings on cholesterol and pulse rate are negative so far, we do have some interesting positive findings to present with regard to cigarette smoking, a well-known risk factor in coronary heart disease. We turn to these findings in the section that follows.

Cigarette Smoking

Cigarette smoking has been one of the much publicized risk factors in coronary heart disease. In our study at Goddard, we asked persons to indicate the actual number of cigarettes they typically smoke in a day. The participants in the study who do smoke report smoking an average of twenty-four cigarettes per day. The data which we shall now present are for only those persons who smoke one or more cigarettes per day. Those who smoke no cigarettes are

excluded since they would skew the distributions if included.

Some interesting results present themselves when we compare the persons who had their secretaries keep a tally of their work load with those persons who did not have a secretary keep a tally. Specifically, forty-four out of 189 or twenty-three percent of the non-tally volunteers returning the questionnaire smoke. By contrast, eleven out of twenty-five or forty-four percent of the volunteers who had secretaries keeping tallies for them smoke. The differences in the proportions of persons who smoke in these two groups are statistically significant ($\chi^2 = 3.94$, $p < .05$). But, why the striking difference?

Earlier we noted that most of the volunteers for the tally part of the study are administrators. Perhaps administrators smoke more. While administrators tend to smoke more than engineers and scientists, the differences are minimal ($\chi^2 = 2.77$, n.s.).

Another possibility is that tally volunteers, having secretaries, also have higher formal status with its accompanying responsibilities than do non-tally volunteers. While this may be so, we find that formal status as measured by G.S. level and salary, shows no relationship to the number of cigarettes a person smokes. Therefore, it must not be formal status which accounts for these differences in smoking among tally and non-tally volunteers.

With regard to responsibilities, however, we find quite a different picture. On page 21, Table 2 presents the average percent of time tally and non-tally volunteers report spending in various responsibilities. We see here that on three of the responsibilities there are significant differences between the two groups. Tally volunteers report spending 40.2 percent of their time being responsible for the work of others while non-tally volunteers report that this

TABLE 2

**Mean Percent of Time Spent Carrying Out Various Responsibilities
by Tally and Non-tally Volunteers**

Type of Responsibility	Volunteer		
	Tally	Non-tally	p <
Work of others	40.2	27.4	.01
Other's futures	15.6	7.0	.001
Money	11.8	9.6	n.s.
Equipment	3.6	9.1	.05
Projects	29.2	51.6	n.s.

responsibility takes up on the average only 27.4 percent of their time. This difference is significant at the .01 level. Tally volunteers also spend over twice as much time in responsibilities having to do with others' futures as do the non-tally volunteers: 15.6 percent compared to 7.0 percent. This difference is significant at the .001 level. While both tally and non-tally persons spend less than ten percent of their time on responsibilities for equipment the tally persons do spend significantly less time: 3.6 percent of the time as compared to 9.1 percent of the time. These findings are interesting in light of the responsibility hypothesis we mentioned earlier. The hypothesis predicts that person-oriented responsibilities such as for another person's work and future should be related to heart disease while object-oriented responsibilities such as for budgets, equipment, etc., should be unrelated to heart disease.

Now the crucial question is do any of these responsibilities on which these two groups differ also relate to cigarette smoking? When we look at the data in Table 3 (page 23), we find that this is indeed the case. The percent of time spent carrying out responsibility for the work of others correlates .31 ($p < .05$) with number of cigarettes smoked. The percent of time spend in responsibility for others' futures correlates non-significantly but in a positive direction, .08. Responsibility for money, equipment, and projects also correlates non-significantly but negatively with number of cigarettes smoked.

Overall, the set of findings suggest that the reason the tally volunteers smoke more is because they have more person-related responsibilities than the non-tally persons. Whether having more of these types of responsibilities makes one tend to volunteer more often for such tallies remains to be seen. Perhaps, having a secretary who can observe one's activities for three days is a luxury

TABLE 3
Correlation between Percent of Time
Spent in Various Responsibilities
and Number of Cigarettes Smoked*

Responsibility for	r
Work of others	.31**
Others' futures	.08
Money	-.22
Equipment	-.19
Projects	-.08

* for persons smoking 1 or more cigarettes per day.

** $p < .05$

provided to persons with more of the types of responsibilities we have just been describing.

Another preliminary interpretation of these findings is that persons who do smoke do tend to volunteer for more activities. This interpretation is consistent with the notion that persons who smoke are also persons who seek stimulation or arousal, smoking being an oral form of such arousal. Indeed, studies of college students who volunteer for psychology experiments show that the volunteers score higher on measures of arousal-seeking than non-volunteers and that arousal-seeking is a central factor in tobacco smoking among college students (Schubert, 1964, 1965). Such persons could be expected to take on more activities, perhaps even overload themselves intentionally to provide more stimulus inputs from their work environment. It is also possible that smoking could act as a stimulant arousing the person to seek out even more stimuli and work.

We cannot tell with the present data whether cigarette smokers are more likely to overburden themselves with work as part of the same arousal-seeking behavior that causes them to smoke or whether smoking causes them to seek arousal and in the process overburden themselves. Nevertheless, we do have additional data which show that persons who smoke more seem to be more overloaded in their work.

Using data drawn from the tallies kept by the secretaries, we find that objective quantitative overload and number of cigarettes smoked for persons smoking one or more cigarettes per day are positively related ($r = .58$, $p < .05$). In other words, persons with more phone calls, office visits, and meetings per given unit of work time also smoke more cigarettes than persons with fewer phone calls, office visits, and meetings per given unit of work time.

Cigarette smoking also correlates positively with the person's report of

a tendency toward environmental overburdening ($r = .36, p < .01$). Environmental burdening is a cluster developed in earlier research carried out by Stephen Sales as part of a study aimed at developing a personality measure of behavior Type A. Sales defines environmental burdening in his cluster of items as:

"The reported presence of the subject in an environment in which he experiences chronic objective quantitative overload. Reported exposure of the subject to constant deadlines, deadline pressures, and job responsibility."

In other words, the environmental overburdening cluster from the Sales measure of Type A is a measure of subjective quantitative overload. In fact, environmental overburdening correlates .44 ($p < .01$) with our subjective quantitative overload factor.

Another interesting characteristic of smokers is that they score high on a cluster which measures the extent to which they feel impatient about the extent to which their profession and NASA is advancing knowledge and accomplishing goals. Typical items in measuring "impatience with advancement of the profession" express dissatisfaction with statements such as (a) The rate at which technological developments are occurring in your field. (b) The pace at which the profession, field, or area is developing. Persons who feel that the rate or pace is very little smoke more than those who feel the pace is great ($r = -.32, p < .05$). One explanation for this relationship might go as follows: (a) we have already suggested that smoking is symptomatic of arousal-seeking behavior; (b) arousal-seekers are persons who tend to perceive their environment as less stimulating than they want it to be--therefore, they seek arousal. (c) Consistent with this perceptual bias is their view of the rate at which the profession is developing. Things are not happening as fast as they should in their view, and thus, those who smoke more also report greater impatience with the rate of technological and professional development in their field.

Another finding of interest is the relationship between number of cigarettes smoked and number of reported visits to the health dispensary on the base. These two variables are inversely related ($r = -.31, p < .05$). That is, the more people smoke, the less often they visit the dispensary. There are a number of possible interpretations we can make about this finding. First of all, smokers may be less concerned about their health than non-smokers. Thus, they not only smoke, but they also make little use of health facilities. They may show less hypochondriasis than non-smokers which accounts for their low frequency of illness behavior. Second, smokers may not visit the dispensary as often because they are already subjectively as well as objectively overloaded with work. In fact, we have just presented evidence which supports this explanation. And, of course, both explanations may jointly account for the results just presented.

While dispensary visits and cigarette smoking are negatively related, volunteering for yearly NASA health examinations and cigarette smoking are unrelated ($F = .19, n.s.$). Why there should be this difference in findings regarding these two types of illness behavior is not clear, but they are worth noting since physicians frequently derive health statistics on smoking in their patient population from both dispensary visits and from voluntary yearly examinations.

Finally, we find that smoking is also correlated with pulse rate ($r = .35, p < .05$) and with systolic blood pressure ($r = .32, p < .05$).

What, then, is the overall profile that we get of the heavy cigarette smoker? The findings we have just discussed are summarized in Figure 3 on the following page. They provide a picture of a person who tends to

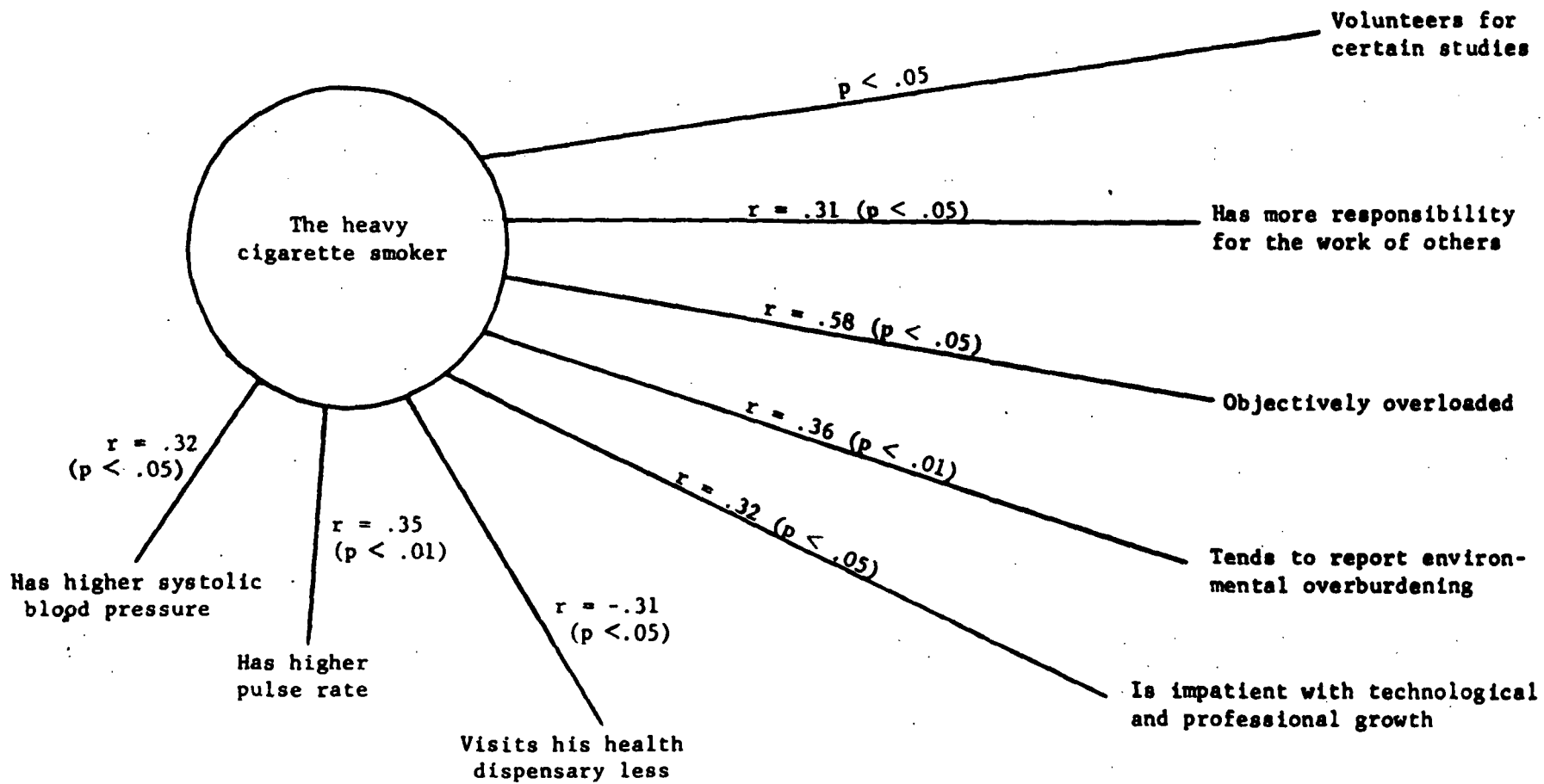


Figure 3: A profile of the cigarette smoker.

volunteer for certain activities -- a step towards more overload. Furthermore, the heavy smoker is more likely to be objectively overloaded and tends to characterize himself as being environmentally overburdened. He has more responsibility for the work of others, and he is impatient with the rate at which technological growth and the growth of his profession is proceeding. Perhaps ironically, while he visits his health dispensary less, he may be in poorer health having higher systolic blood pressure and higher pulse rate.

Some Differences between Administrators, Engineers, and Scientists

Now let's turn to some data which bear on one of the central goals of our research. Namely, to account for the occupational differences in coronary heart disease which have been noted by Dr. Carlos Villafana and Mrs. Mockbee among administrators, engineers, and scientists. In Table 4 (page 29) we find a summary of some early findings on these three occupational groups. We have defined occupation here in terms of what the Goddard volunteer labeled himself on the questionnaire.

First of all, we note that as one moves from administrators to scientists, one finds significant decreases in average age ($p < .001$). The administrators average about forty-four years old while the engineers have an average age of thirty-nine. The scientists average slightly over thirty-five years of age. Since we already know that coronary heart disease appears more often in older individuals, it will be important to control on age where we feel that it is related to certain of our dependent variables such as serum cholesterol level. Surely, one could argue that administrators have a higher incidence of cardiovascular disease and hypertension on the basis of age alone unless one could control on that variable while searching for other differences.

TABLE 4

**Occupational Differences in Certain Background,
Health, and Job Stress Variables**

Measures	Occupation			
	Administrator	Engineer	Scientist	p
Age	44.4	39.0	35.6	.001
Average schooling	completed college	some grad. school	masters	.001
% participate in annual NASA health exams	71.0	59.0	26.0	.001
# cigarettes smoked ¹	31.6	18.8	19.9	.05
% smokers	33.0	22.0	21.0	n.s.
Systolic blood pressure	134.8	128.6	131.3	.05 ²
Subjective quantitative overload cluster	3.7 ³	3.4	3.1	.001
Days elapsed until questionnaire returned	19.9	13.1	14.5	.05
Subjective qualitative overload factor	1.8	2.0	2.1	.05
Opportunity to use administrative skills	3.6	3.0	2.6	.001
Opportunity to use one's education, talents, and abilities	3.3	3.2	3.8	.001
Role conflict	2.2	2.1	1.9	.05

¹ For persons smoking one or more cigarettes per day.

² Significant when corrected for age differences.

³ These values are based on a five-point rating scale where 1 = "very little" and 5 = "very great."

The next row in Table 4 shows that there is a significant increase in level of education as one moves from administrators to engineers to scientists ($p < .001$). Administrators on the average complete college or undergraduate school. Engineers tend to have some graduate school work, while scientists average a masters degree. Education may be a relevant variable in the study of coronary heart disease. For one thing, we can theoretically suggest that education provides an opportunity for a person to learn effective modes for coping with both quantitative and qualitative overload. Experience in colleges and universities has often been noted as providing skills and practice in handling many complex situations. Such training could provide a person with coping skills for dealing with role conflict on the job. A recent study by Hinkle and his colleagues (1968) at Bell Telephone provides some support for this hypothesis: They found in a three-year study of 1,160 male employees that myocardial infarctions were twice as prevalent among non-college educated men compared to college men. All other causes of death were evenly distributed among the two groups.

Next in Table 4 we see that 71% of the administrators, 59% of the engineers, and only 26% of the scientists participate in annual NASA health examinations. The differences in participation rates should be of interest to persons using the medical examinations to derive some estimates of prevalence of various coronary conditions. Data drawn from such examinations may be most valid for describing the general health conditions of the administrators but could be misleading in describing the health conditions of the scientists. Perhaps only the healthiest of the scientists participate (which would provide a picture of the scientists which would underestimate the amount of obesity, silent heart pathologies, etc.). Since the volunteer rate among scientists is much higher for this study than it is for the health examination, we will be able to make

some comparisons on variables like smoking, obesity, and hypertension to see whether data derived from the yearly health examinations under-, over-, or correctly estimate the prevalence of some of these risk factors.

Continuing, we see that among those who smoke, administrators are heavier smokers than are engineers and scientists (31.6 cigarettes per day compared to 18.8 and 19.9 respectively). There are also a greater percentage of smokers among the administrators than among the engineers and scientists, although the differences are not significant.

With regard to systolic blood pressure, the administrators again score higher than the engineers and the scientists (134.8, 128.6, and 131.3 respectively for the three groups). The difference across the three groups is significant ($p < .05$) when we correct for age differences between the three groups.

What about overload? How do these three occupational groups differ with regard to this variable which has often been implicated as a risk factor in heart disease? First of all, we see that administrators report being more subjectively overloaded than engineers and than scientists. The scientists are the least overloaded of all. The type of overload we are talking about here is subjective quantitative overload--too much work to do given the amount of time to do it in. The items in this measure are quite similar to the items in our subjective quantitative overload factor which we derived from a study of overload in university professors. In fact the subjective quantitative overload cluster we are using here correlates quite highly with the subjective quantitative overload factor from that previous study ($r = .66, p < .001$).

We get some additional insight into the nature of overload for the administrators and the other two groups when we look at how long it took each occupational group to complete and send in the questionnaire they were given for this

study. Almost twenty days elapsed on the average until questionnaires were received back from administrators compared to slightly over thirteen days for the engineers and 14.5 days for the scientists. The differences in elapsed time across the three groups is significant ($p < .05$) and suggest that administrators are objectively as well as subjectively overloaded.

Now let's turn to qualitative overload. Here the picture is quite different. It is the scientists who report the most qualitative overload followed by the engineers, and then the administrators. Thus, with regard to the types of subjectively felt overload reported by different occupations, it appears that administrators suffer more from quantitative overload while scientists suffer more from qualitative overload. These findings are consistent with some earlier work on university professors and university administrators carried out here at the Institute for Social Research. In that study (French, Tupper, & Mueller, 1965) the professors (who seem analogous to our scientists) reported feeling low self-esteem due to the qualitatively overloading aspects of their work--it was important to do a professionally high quality job even if it took some time to complete it. The university administrators, on the other hand, reported feeling low self-esteem not from qualitative overload but from quantitative overload--they couldn't hope to do the best job on everything, but they were expected to handle a certain quantity of work in a given time. Perhaps we shall find that other types of job overload only constitute sources of stress for one occupational group but not for another.

Continuing down Table 4, we notice that administrators report more opportunity to use their administrative skills. Engineers report less opportunity, and scientists report the least opportunity. The fact that administrators do have more opportunity could suggest that they also have greater chances to become involved in role conflicts with other individuals. We note in the last

line of Table 4 that administrators do tend to report more role conflict, followed by engineers, with scientists reporting the least amount of role conflict. The differences across the three groups are significant, and are supportive of some potentially stressful outcomes which would derive from having a lot of opportunity to use one's administrative skills.

Finally, we note that while administrators have the most opportunity to use their administrative skills, they report less opportunity to use their education, talents, and abilities than do the scientists. Both they and the engineers report being under-utilized, while the scientists report having the most opportunity to utilize all of their skills, abilities, and education.

To summarize the picture at this point, we get a view of the administrator as older, less educated, quantitatively more overloaded, and more likely to experience role conflict than the scientist. The administrator also smokes more and has a higher systolic blood pressure than the scientist. The scientist, on the other hand, is better educated, qualitatively more overloaded, and is less likely to get into role conflict. The scientist also smokes less and has lower systolic blood pressure. The engineer falls somewhere between these two occupational groups.

What About Responsibility?

We have already noted that responsibility for the work of others is correlated with number of cigarettes smoked. Do the three occupational groups differ in terms of the amount and types of responsibilities they report? Table 5 (page 34) presents data on the three occupations which helps us answer these questions.

First of all we see that an index of the overall amount of responsibility

TABLE 5

Occupational Differences in Responsibility

Measure	Occupation			
	Administrator	Engineer	Scientist	p
Amount of responsibilities index	3.4	3.0	2.9	.01
% time carrying out responsibility for:				
a) others' work	42.9	27.1	17.1	.001
b) others' futures	12.1	6.3	6.7	.01
c) money	11.2	10.8	6.5	.05
d) equipment	4.4	9.3	12.0	.05
e) projects	29.6	46.6	72.2	.01

reported differs significantly across the three occupations ($p < .01$). Administrators report the most responsibility, followed by engineers, with scientists reporting the least.

Now let's look at the more specific types of responsibility. Administrators spend about 42% of their time carrying out responsibilities for others' work while engineers spend only about 27% of their time doing so, and scientists spend only about 17% of their time doing so. The difference across these three groups is quite significant ($p < .001$). Similarly administrators spend the most time of the three groups on responsibilities for others' futures--almost twice as much time as do the engineers and scientists (12.1% versus 6.3% and 6.7% respectively). Thus, with regard to the two responsibilities for people, which we have already labeled as reflecting the "responsibility hypothesis" in coronary heart disease, the administrators report spending the greatest amount of time on the average.

With regard to responsibilities for money, administrators spend slightly more time on the average than do engineers. The scientists spend the least time of all three groups on this responsibility.

The pattern, however, is reversed with regard to responsibility for equipment and projects. Here the scientists spend the most amount of time compared to the administrators and engineers. In fact, the scientists and engineers spend, on the average, the greatest segments of their time carrying out responsibilities which should not be associated with coronary heart disease. The scientists spend 72.2% of their time in responsibility for projects while the engineers spend 46.6% of their time (and administrators spend 29.6% of their time in responsibility for projects). On the other hand, the largest segment of time for the administrators is spent carrying out responsibilities for the work of others--a responsibility which should be associated with coronary heart

disease according to the responsibility hypothesis.

With regard to responsibilities then, the administrators report more of them overall, and they also report more responsibilities which are people-oriented than do the engineers and scientists. The engineers and scientists report more object-oriented responsibilities than do the administrators.

Personality Differences between the Three Occupations

Now let's turn to Table 6 (page 37) which presents some measures of personality on which the three occupational groups differ. First of all, we see that the administrators appear to score lower on a measure of rigid personality, while engineers fall in the middle and scientists score highest. This measure is a scale from the California Personality Inventory which characterizes a person who is unwilling to give in to other persons' points of view, and is inflexible when it comes to comprising his own needs to meet someone else's.

This measure of personality is of interest because of some previous work done in a nationwide study of role conflict which linked such conflict to the rigid personality (Kahn et al., 1964). Kahn and his colleagues found that persons who were placed in objective role conflicts were less likely to report feeling that a conflict was present if they were rigid personalities. On the other hand, if they were flexible personalities, they were more likely to feel the presence of the conflict. The explanation given was the flexible person always bending with the wind, put himself into more conflicts by attempting to cope with all points of view by meeting them simultaneously. The rigid person, on the other hand, would shut himself off from the conflict perhaps by ignoring its existence, and thus avoid the discomfort of feeling that a

TABLE 6
Occupational Differences in Personality

Measure	Occupation			
	Administrator	Engineer	Scientist	p
Rigid personality (Flex.-rigid. scale)	2.3 ¹	2.4	2.5	.01
Involved striving	5.2 ²	4.8	5.0	.05
Positive attitude toward pressure	5.2	4.9	4.8	.05
Environmental overburdening	5.6	5.1	5.4	.05
Leadership	5.0	4.3	4.2	.05
What I Am Like (Type A)	3.5	3.3	3.2	.05

¹ These values are based on a four-point scale where 1 = low rigid and 4 = high rigid.

² These values are based on a seven-point scale where 1 = low on the personality trait and 7 = high on the personality trait.

conflict really existed. As we have already noted, the administrators tend to report more role conflict than do the engineers and scientists. Perhaps this is because the administrators are more flexible and thus set themselves up for such conflict.

The next five personality dimensions in Table 6 were all designed to measure the Type A coronary-prone personality. On all of them the administrators score the highest. Administrators seem to see themselves as higher on involved striving in what they do, higher on liking pressure and perhaps seeking it out, and higher on tending to become overburdened (this personality measure, as we have noted is positively correlated with number of cigarettes smoked) than do engineers and scientists. They also score higher on leadership, a dimension which could be looked at as a tendency to take over positions of responsibility for the welfare and work of others. Finally, there is a significant tendency for administrators to score highest on a three-item measure of Type A called "What I Am Like." This measure, correlates .80 with the Jenkins Activity Scale, a validated measure used to predict to Type A personality (Jenkins, 1967).

In summary, then, we see that the administrators, compared to the engineers and scientists, tend to suffer more quantitative overload but less qualitative overload; and they also appear to be under more stress from responsibilities for people, but they have less responsibility for projects and equipment. Furthermore, they also seem to have more of the personality characteristics which typify the Type A coronary-prone personality. The scientists generally tend to be lowest on these potential risk factors while the engineers are somewhat intermediate.

A Brief Look at Person-environment Fit

Before concluding our presentation of data, let's turn to the notion of

poor person-environment fit as a factor which could lead to coronary heart disease. We noted earlier that we had divided the administrators and the engineers into two further groups. These are administrators in administrative environments, administrators in engineering environments, engineers in engineering environments, and engineers in administrative environments. The first and third categories were labeled examples of good fit; and second and fourth categories were called examples of potentially poor fit.

We now have some preliminary data which suggest that poor fit may affect a person's health. Table 7 (page 40) presents data on the relationships between job environment and blood pressure for administrators. We assume that an administrator is better fitted to an organizational unit which is primarily administrative in mission and climate but he is less well fitted to an engineering unit where most of the other personnel are engineers. To obtain a measure of environment in this case, we asked the respondent to estimate what percent of his environment was administrative and what percent was engineering. Environment was defined as follows:

"Aside from your immediate job, your work life may be affected by the wider environment of your section, branch, division, or directorate. As far as it affects your job, is this wider environment mostly administration, engineering, or science? Considering the mission, the people, and the organizational climate my organizational environment is: . . ." (p. 29, questionnaire).

Table 7 shows that the higher the percent of environment characterized as administrative in nature, the lower both the systolic and diastolic blood pressures tended to be. Thus, good fit as defined here is related to low systolic and diastolic blood pressure ($r = -.38$, $p .01$; and $r = -.28$, $p .01$ respectively). Similarly, the higher the percent environment characterized as

TABLE 7

Relationships between Job Environment and Blood Pressure for Administrators

Environment	Blood Pressure	
	SBP	DBP
% Administration	-.38	-.28
% Engineering	.28	.27

engineering the higher the blood pressure. Thus, poor fit for administrators associated with high systolic and diastolic blood pressure ($r = .28, p < .01$; and $r = .27, p < .01$ respectively).

Interestingly enough, this lack of fit does not serve as a source of stress for the engineers. The correlations between percent environment, either engineering or administrative, and blood pressure are close to zero and non-significant. This lack of correlation for the engineers, but its presence for the administrators, suggests that certain types of poor fit may serve as a source of stress for one occupational group but not for another. In our continuing analyses we shall be looking for other types of stresses which may affect one occupational group but not the other.

Discussion

In Diagram A we presented a model of coronary heart disease which implied that personality, type of occupation, various forms of responsibility and other job stresses, may affect various physiological risk factors and cause coronary heart disease. The results that we have presented so far are a long way from adequately testing the model, yet they provide a certain amount of encouragement in leading us to believe we are on the right track. We have found differences among administrators, engineers, and scientists with regard to variables which seem peculiarly associated with heart disease. These differences are in terms of physiology, personality, reported job stress, and smoking. What is lacking are the types of information needed to pin down the causal links between these various panels of variables in the manner suggested in Diagram A.

In some cases, we have found administrators to be relatively high on a particular variable such as a Type A personality variable, yet have found no

relationship between that variable and our physiological risk factors. In other cases, we have found some stronger links as is true of the relationship between responsibility for the work of others and cigarette smoking, and between cigarette smoking and blood pressure. What is the explanation for a failure to find relationships between some of the job stress measures which differentiate administrators from engineers and scientists and physiological measures like cholesterol and blood pressure?

For one thing, some of these job stresses and personality variables may relate to physiological risk factors other than the ones being examined in our research. Since there is much literature linking job stress and personality to coronary heart disease, it may be wise to expand our search for related physiological risk factors in coronary heart disease.

Second, some of the relationships between job stresses and physiological risk factors may be masked by personality. As an example, we may find, upon further analysis, that job overload is likely to increase blood pressure if a person is personality Type A, but likely to decrease blood pressure if the person is Type B. Hence the relationship between overload and blood pressure would be cancelled out in a mixed group comprised of both Type A and Type B persons. To give another example, we might find that persons who are high on the need for social approval from others (such as measured by the Crowne-Marlowe) might show increases in cholesterol when they are overloaded with work. Persons who are low on this need for social approval might show no change in cholesterol as their work load changes. Why might this be so? We might assume that for the group of people who value social approval overload can only mean one thing --a potential opportunity to fail at their work and thus lose the social approval of others which they want so much. Thus, overload is stressful and would raise their cholesterol. On the other hand, while overload might cause the persons

low on need for social approval to lose such approval, such a threatened loss in social approval would probably not cause their cholesterol to rise because they don't value social approval very highly to begin with. We are already beginning to find relationships of this type which suggest that different personalities take stress in different ways.

Overall, then, we are beginning to pick up relationships between certain types of job stress and risk factors (such as smoking) in heart disease. Furthermore, we are beginning to find differences among the three occupational groups we are studying which appear to be more than coincidentally related to coronary heart disease. An almost mandatory next step following the identification of these relevant variables, is a longitudinal study to begin to carefully tackle the problem of distinguishing between cause and effect in our model.

APPENDIX

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LEAVE TAKING AND OVERTIME BEHAVIOR

AS RELATED TO DEMOGRAPHIC, HEALTH, AND JOB VARIABLES

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The Division of Occupational Medicine and Environmental Health of NASA Headquarters is planning a NASA-wide study of the leave taking and overtime behavior pattern of its employees. It is anticipated that the relationships of demographic, health and job related variables to the various types and amounts of leave and overtime taken can be ascertained for each installation and the meaningful interrelationships studied.

Greater knowledge concerning leave taking behavior of employees is desired for at least the following reasons: 1) to detect administrative, job, and employee problems at an installation where leave taking behavior is associated with medical or psychological factors, 2) to determine the relationships between the types and amounts of leave and overtime taken and the physical condition of the employee, 3) to determine how periodic increases in an installation's work load with its concomitant stress is related to leave taking and, 4) to provide data for intra as well as inter installation comparisons of leave taking and overtime behavior as related to the demographic, health, and job variables of the employees.

Before attempting a broader study, it was deemed desirable to gather data on a single installation chosen to exemplify the major factors upon which leave taking behavior patterns may depend. From data gathered at the selected installation, a research model would be developed. The model would not only stipulate the precise variables for which data would be gathered but, when carefully scrutinized for omissions, redundancies, and needed modifications, would provide a valid design for future data collection, analysis, and interpretation. Although the generalizability of the results of the present study to other installations is risky, the design model produced in this investigation is valid for conducting intra-installation studies and thus obtaining basic data from which later inter-installation studies using a related comparative model can be made.

METHOD AND PROCEDURES

The installation chosen was one which undergoes periods of drastically increased activity associated with the performance of its primary mission. During these periods, which range from three to five exaggerated peaks per year, tension runs high, long hours of continuous work by certain personnel is demanded, and personal convenience and comfort are sacrificed

for the good of the mission. During the data collection phase of the present study, five of these work activity peaks occurred. (Figure 1)

As can be seen from Figure 1, the peaks of increased activity occurred at fairly separated intervals. Data were collected in relation to two of the selected peaks: the first and fourth. These two were selected because they occurred at two completely different times of the year and thus involve the sampling of two contrasting vacation periods, probably not equally desirable or utilized for the taking of annual leave. One of these peaks occurred in January, the other in July.

Although leave information was gathered throughout the year, data after December 17th were not used in any analysis because of the usual excessive use of annual leave during the latter part of each December.

The following dependent variables were ultimately selected and appropriate measurements obtained on them throughout the study. (Figure 2)

An attempt was made to obtain complete data on 51 subjects. For various reasons some items of data were missing on some of the subjects. When it was found that incomplete data existed on a subject for a particular comparison, he was excluded from the analysis. This resulted in the maximum number of subjects involved in any one statistical comparison being 48; the minimum number involved in any one comparison was 35.

The following charts not only further describe the sample of subjects used in the study but provide, as well, definitions of the independent variables hypothesized as being related to the overtime and leave taking dependent measurements.

Let us look more closely at these independent variables. (Figure 3)

Chart 4 shows the distribution of subjects by health rating. A rating of 2 indicates all functions and capacities were reported within normal limits; 1 indicates only non-permanent or correctable abnormalities reported, i.e., myopia, hernia, etc., 0 indicates one or more potentially incapacitating abnormalities reported, i.e., hypertension, heart disease, etc. Thus, the higher the health rating the better the health of the employee. Since those subjects receiving ratings of 2 or 1 were essentially healthy subjects, they were combined in the statistical analyses as a single group and contrasted with those subjects receiving a rating of 0. Composite health ratings were assigned to the subjects based upon independent judgments by a physician who used clinical criteria and by a bio-statistician who based his ratings on norms, projection tables and other statistical criteria. (Figure 4)

The distribution of subjects by age is presented in figure 5. Mean age was 42 years, range 25 to 58 years. (Figure 5)

Figure 6 presents the distribution of subjects by sex. (Figure 6)

The distribution of subjects by GS grade is shown in Figure 7. The distribution is clearly dichotomous. The lower group was almost exclusively clerical. (Figure 7)

In Figure 8 the distribution of subjects by step level within grade is shown. The slightly positively skewed curve indicates that the bulk of the subjects were at the lower step levels, which are earned primarily through automatic increases. (Figure 8)

The distribution of subjects by time in months since last promotion is shown in Figure 9. The median number of months since last promotion was 35 with a range from 2 to 102 months. (Figure 9)

Figure 10 presents the distribution of types of jobs held by the subjects. Sixty-six percent of the sample were scientists, engineers or technicians; 13 percent were managers and, 21 percent were clerical. (Figure 10)

The distribution of length of total federal service of the subjects in months is shown in Figure 11. In terms of years, the mean total federal service was 17.3, and the range was from 1.5 to 36 years. (Figure 11)

Figure 12 presents the distribution of subjects by their educational level. Each subject's educational level was recorded in years with an individual being given one year credit for any graduate work past a Bachelor's degree, and two years' credit past a Bachelor's if he had been awarded a Master's degree. (Figure 12)

Figure 13 shows the number of dependents reported by the subjects. The mean number of dependents was 2.7, and the range was from 0 to 8. (Figure 13)

Distribution of office assignment is shown in Figure 14. It is to be noted that the spread of subjects throughout the various offices was essentially rectilinear. (Figure 14)

The demographic data comprising the independent variables were secured by means of questionnaires. A questionnaire was completed on each subject by a clerical helper who obtained the required information from the subject's personnel file.

Overtime, and annual, sick and compensatory leave times were obtained from time cards and were recorded as hours of leave taken.

The health rating for each individual was based upon the results of his most recent physical examination available.

RESULTS

The results of this study have been gathered to provide information concerning the following three problem areas: 1) the relationship of certain demographic and job variables to the health of the employee and to his use of overtime and leave, 2) the effects of peak periods of job stress on the overtime and leave taking behavior of employees, and 3) the identification of the characteristics of a model for conducting a NASA-wide study at the intra and inter installation levels to achieve the goals expressed above in items one and two.

Let us now examine the results obtained in this study as to their usefulness in meeting the above goals.

Figure 15 presents the independent variables which were found to be significantly related to the health of the employees. It is not surprising to note that those employees who took the most annual leave as well as sick leave were the ones who had the poorest health ratings. We know that annual leave is often substituted for sick leave and vice versa. Thus there is an acceptable rationale for the existence of the relationship between health and the use of annual and sick leave. What we did find that is of interest to occupational medicine is that the employees who had put in the most overtime were the ones who had the poorest health. (Figure 15)

It is possible, however, that the correlation between overtime and poor health might have occurred because of some third uncontrolled factor. Variables which might have been related to both the health and the overtime behavior of the employees could be statistically controlled by a partial correlation technique with the result that their effects on the correlation would thus be removed. As a basis for performing the partialling operations, all relationships were converted to equivalent, estimated Pearson coefficients of correlation (r). Since we have found a correlation between age and health ratings and between type of job and health rating it is possible that the correlation between overtime taken and health ratings was simply due to the older employees being the ones who filled certain types of jobs wherein their duties required that they work more overtime. Because older employees tend to have poorer health ratings, then the correlation between overtime and health ratings would be harmlessly explained away. When the effect of type of job was systematically removed from the correlation between overtime and health by a partialling technique the following results were achieved: using all type of subjects, i.e., clerical, technicians, managers, and scientists and engineers, the correlation between overtime and health rating dropped from significance at the .05 level to insignificance ($r = .13$). Eliminating the clerical workers from the data (these were all healthy young women) the correlation rose to .26. Eliminating the scientists and engineers as well as the

clerical workers and leaving only the managers and technicians the correlation between overtime and health rose to a significant .63. This trend would appear to indicate that among employees who function as technicians or managers, those who work the most overtime have the poorest health. This finding is in complete accord with other NASA studies which show that the health of the technicians, trades and crafts, and managers is poorer than the health of scientists and engineers. In fact, the incidence of cardiovascular disease is five times higher in the technicians, trades and crafts, and managers (ages 35-54) than it is in scientists and engineers. Is it possible that the results of the present study have revealed that large amounts of overtime adversely affect the health of the trades and crafts and managers but not the scientists and engineers, and that the unhealthy state of the trades and crafts, technicians, and managers as compared to scientists and engineers is due to the interactive effect of their type of job and the overtime they work in performing it?

A further interesting result along this line was the significant correlation yielded by the following analysis: the employees who worked overtime were divided into two groups on the basis of the health ratings. One was classified perfectly healthy and the second was classified as having a potentially disabling condition. Through the use of biserial correlation these groups were correlated with the amount of sick leave each group used. The data yielded a correlation of .52 ($P = .01$). This means that for people who worked overtime, sick persons use more sick leave than well persons, which is not surprising although it does indicate that sick leave is not completely abused. However, when equating all individuals on overtime, i.e., partialling out the effects of differences in overtime used, the correlation jumped to .56 ($P = .01$). This may be interpreted as supporting the hypothesis that the adverse effects of overtime on the health of employees is greater for those employees who are classified as having a potentially disabling condition than those who are classified as healthy.

The second area of interest in this study, i.e., the stress effects of peak periods of mission activity on the leave taking behavior of employees yielded the following results. (Figure 16) The overtime column reflects the peaks and valleys of activity. Annual leave is little used just prior to a launch and most used immediately after launch. Use of sick leave is at a low just prior to launch, increases immediately after launch, and continues to increase as time passes after a launch. Although the sick leave data are not statistically significant, (apparently due to the small number of subjects) the trend is unmistakable in the direction noted. Thus, it appears that the pattern of sick leave use just before launch, just after launch and independent of launch differs from that for annual leave. Several hypotheses may be advanced to account for this, the most tenable perhaps being that the stress of the peak activity associated with a launch produces a steady increase in sick leave during the succeeding months while the effect on annual leave is simply an expected normal rises immediately after launch and throughout the succeeding months.

Let us now look at the present study as suggesting a model for the conduction of future NASA-wide studies of the same type. For an intra installation study, the present approach appears adequate in terms of the categorical information with which it deals. However, there are important questions which cannot be answered from the application of the model because of inadequacies within each category. Future research applying the general concept of the model employed in this study must consider the following necessary modifications:

1) The use of a large number of subjects is a necessity in research of this nature. Since one most often wishes to break down the total number of subjects into categories and then compare one category against another as to their relative degree of possession of some variable, the total number of subjects involved in the analysis is reduced to the sum of the number of subjects in each category dealt with, or in some analyses (such as tests of significance on correlated data) to one half this number. Thus the minimum total N in this type of research is, at best, equal to the sum of the desired N's in each category designated for future analyses.

2) When dealing with employees across such variables as type of job, age, grade, etc., one must be careful not to build gaps into his data. For instance, in the present study we found that type of job was significantly correlated with health. Under scrutiny we found this to be due in certain instances to the fact that the clerical jobs were mostly filled with young, healthy women while, for instance, managers were older and less healthy. The managers were not necessarily less healthy as a function of their type of job but rather because older persons tend to have more physical infirmities. Thus the gap in age between the two groups really accounted for the correlation between type of job and health rating in at least this one instance.

A further requirement in order for this model to operate fully is the need for more complete physical examination data. In the present study only one physical examination report was available for each individual. It is important that the results of at least two physical examinations including laboratory findings and separated by approximately one year be available for analysis if the job, demographic, and overtime and leave variables are to be related to change in health status.

This modified model when applied to a single installation is considered adequate to provide the basic data of use in making inter installation comparisons. Plans are now in process to apply the intra installation model to a second installation and thus make inter installation comparisons possible. As the result of obtaining data in this second instance further reshaping of the research model, where necessary, will be undertaken before it is applied generally to other NASA installations.

FIGURE 1: PEAK PERIODS OF MISSION ACTIVITY DURING THE YEAR OF THE STUDY (ESTIMATED LEVELS)

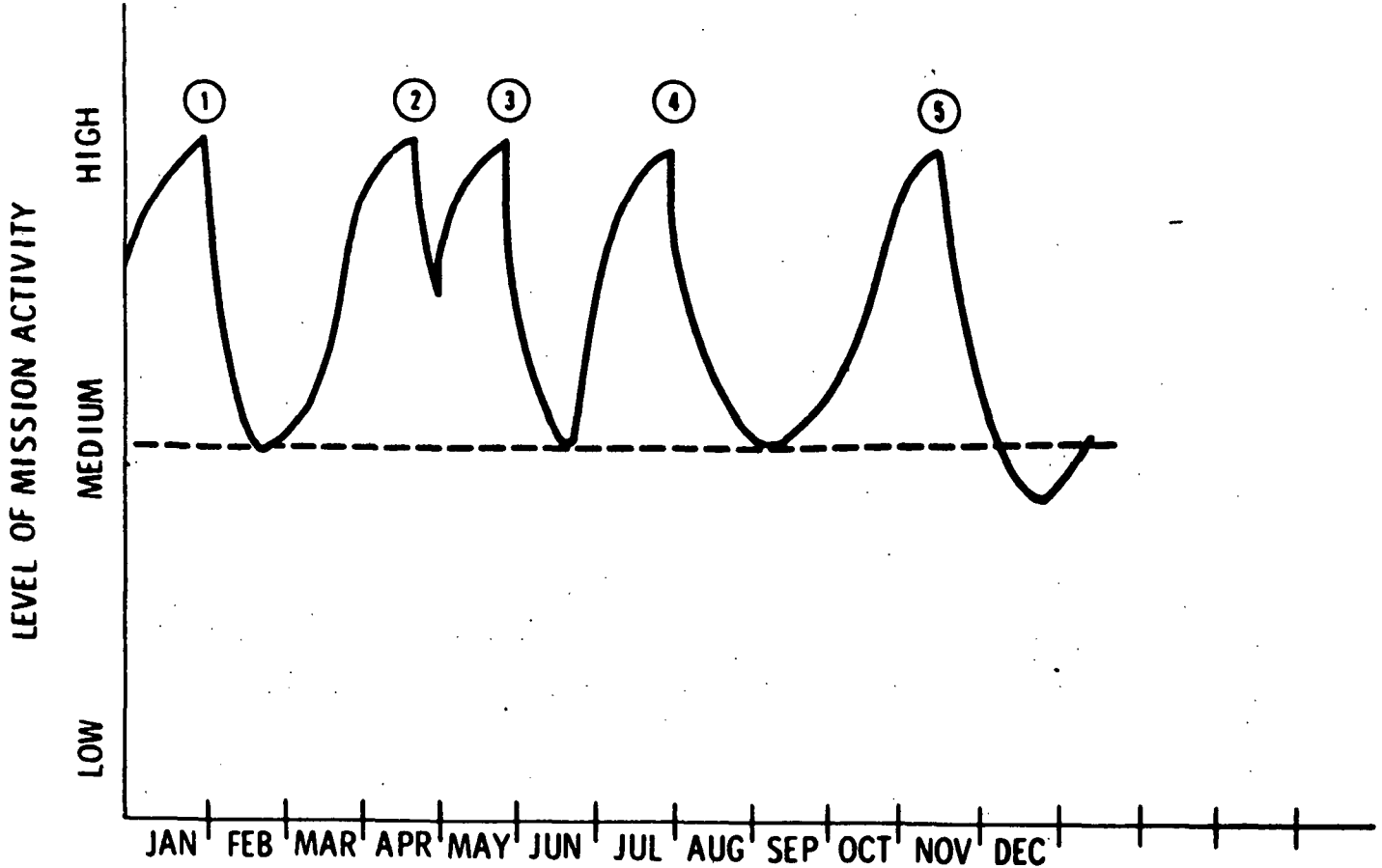


FIGURE 2: DEPENDENT VARIABLES MEASURED IN THE STUDY

- 1) TOTAL COMPENSATORY LEAVE TAKEN DURING THE YEAR
- 2) TOTAL OVERTIME, ANNUAL LEAVE, AND SICK LEAVE, RESPECTIVELY, TAKEN DURING THE YEAR
- 3) NUMBER OF HOURS OF OVERTIME, ANNUAL LEAVE, AND SICK LEAVE (EACH TREATED SEPARATELY) TAKEN DURING OR JUST PRIOR TO A PERIOD OF PEAK MISSION ACTIVITY DURING JANUARY AND JULY, RESPECTIVELY, AND COMBINED AS AN AVERAGE
- 4) HOURS OF OVERTIME, ANNUAL LEAVE, AND SICK LEAVE (EACH TREATED SEPARATELY) TAKEN DURING THE PAY PERIOD IMMEDIATELY FOLLOWING A PERIOD OF PEAK MISSION ACTIVITY DURING JANUARY AND JULY, RESPECTIVELY, AND COMBINED AS AN AVERAGE
- 5) NUMBER OF HOURS OF OVERTIME, ANNUAL LEAVE, AND SICK LEAVE (EACH TREATED SEPARATELY) INDEPENDENT OF THE PERIODS DURING AND SURROUNDING PEAK MISSION ACTIVITY, TAKEN DURING THE SPRING AND FALL, RESPECTIVELY, AND COMBINED AS AN AVERAGE.

FIGURE 3: INDEPENDENT VARIABLES INVESTIGATED IN THE STUDY

- 1) HEALTH RATING
- 2) AGE
- 3) SEX
- 4) GS GRADE
- 5) GS STEP LEVEL
- 6) TIME SINCE LAST PROMOTION
- 7) TYPE OF JOB
- 8) TIME WITH NASA
- 9) LENGTH OF TOTAL FEDERAL SERVICE
- 10) EDUCATIONAL LEVEL
- 11) NUMBER OF DEPENDENTS
- 12) OFFICE WITHIN WHICH ASSIGNED

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FIGURE 4: DISTRIBUTION OF SUBJECTS BY HEALTH RATING

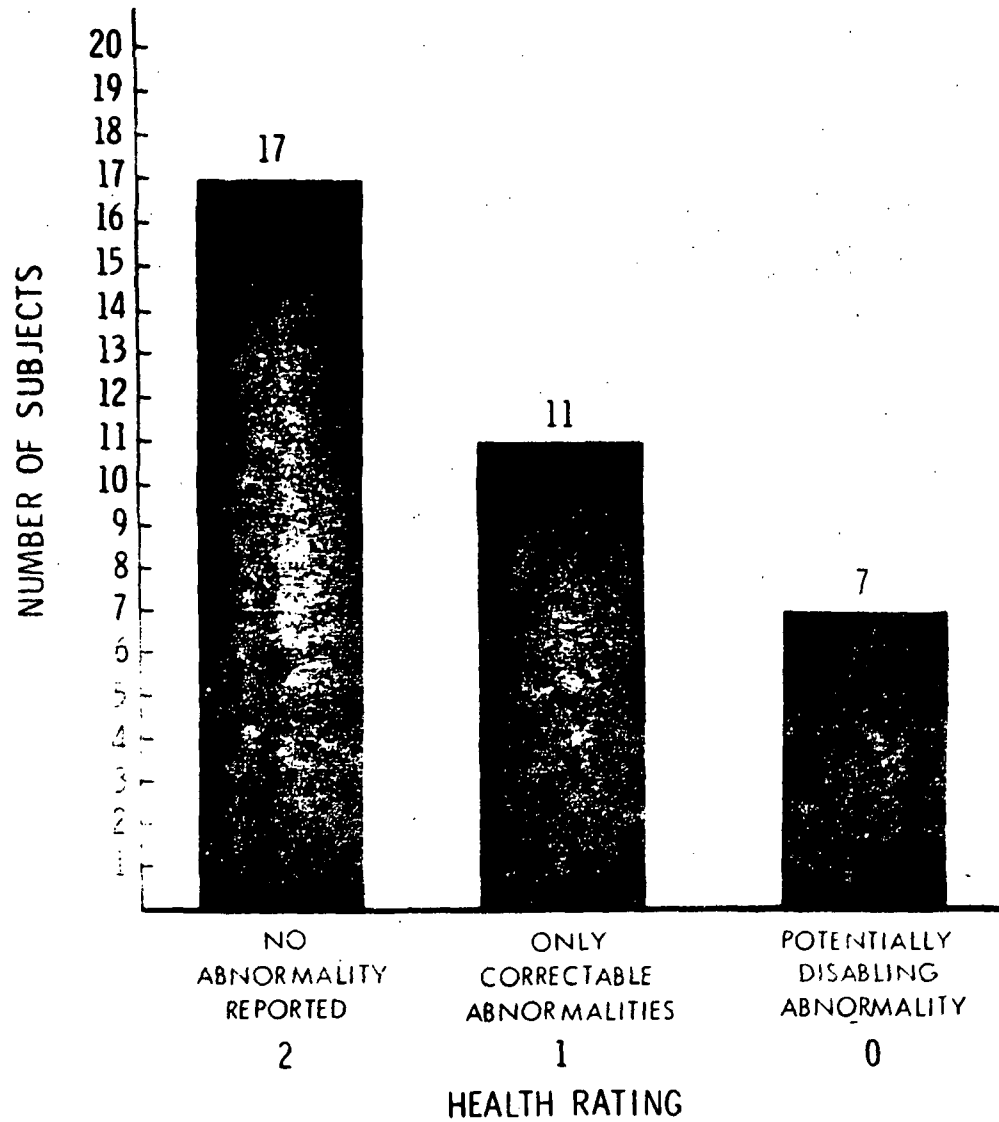
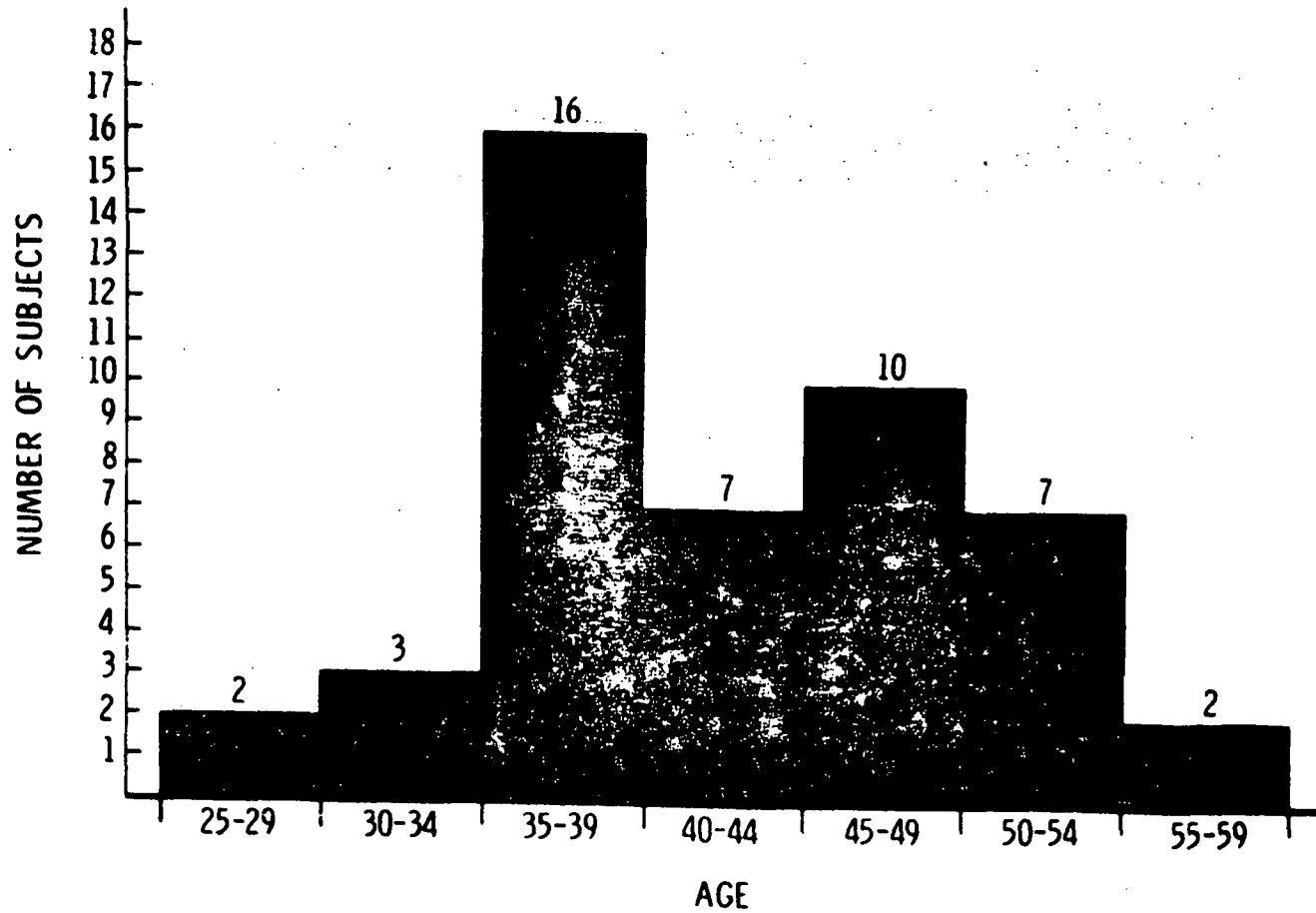


FIGURE 5: DISTRIBUTION OF SUBJECTS BY AGE



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FIGURE 6: DISTRIBUTION OF SUBJECTS BY SEX

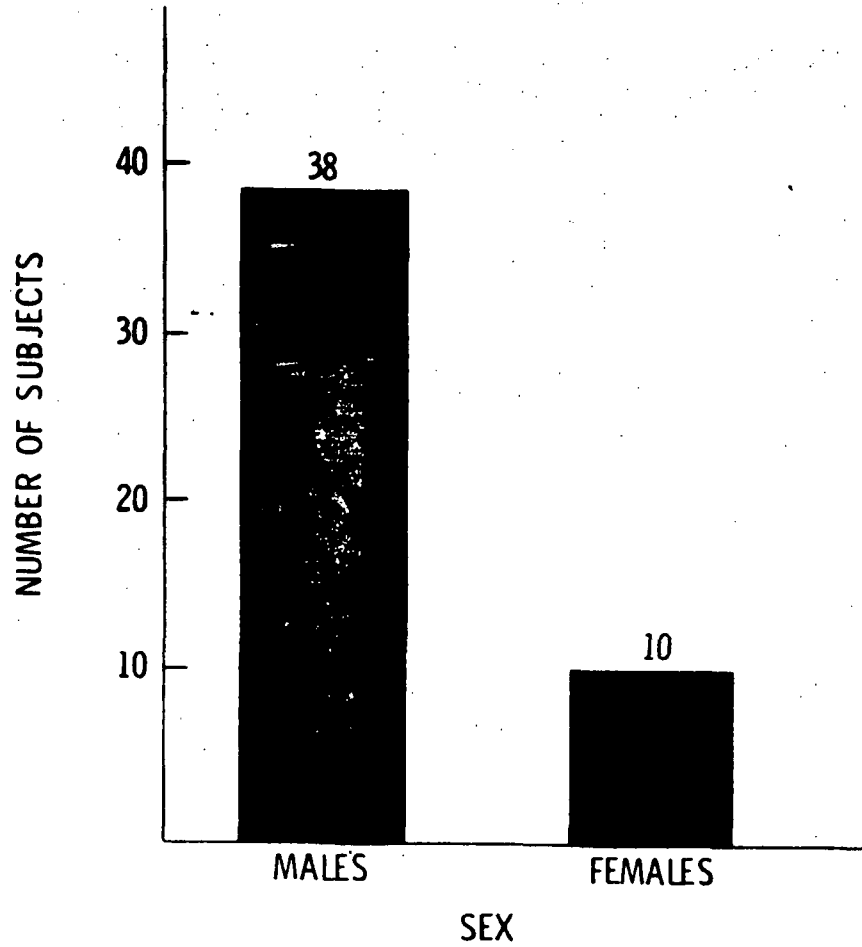
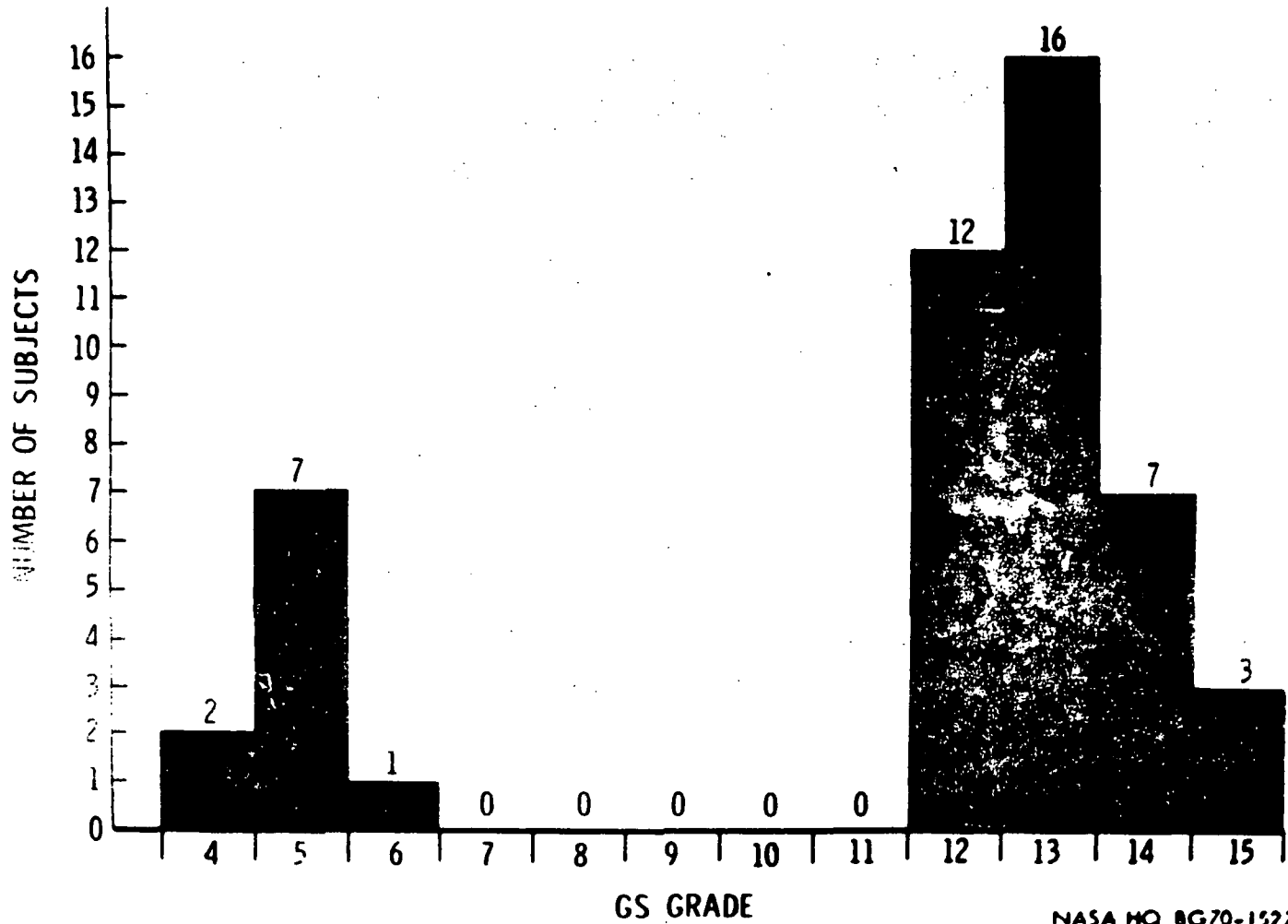
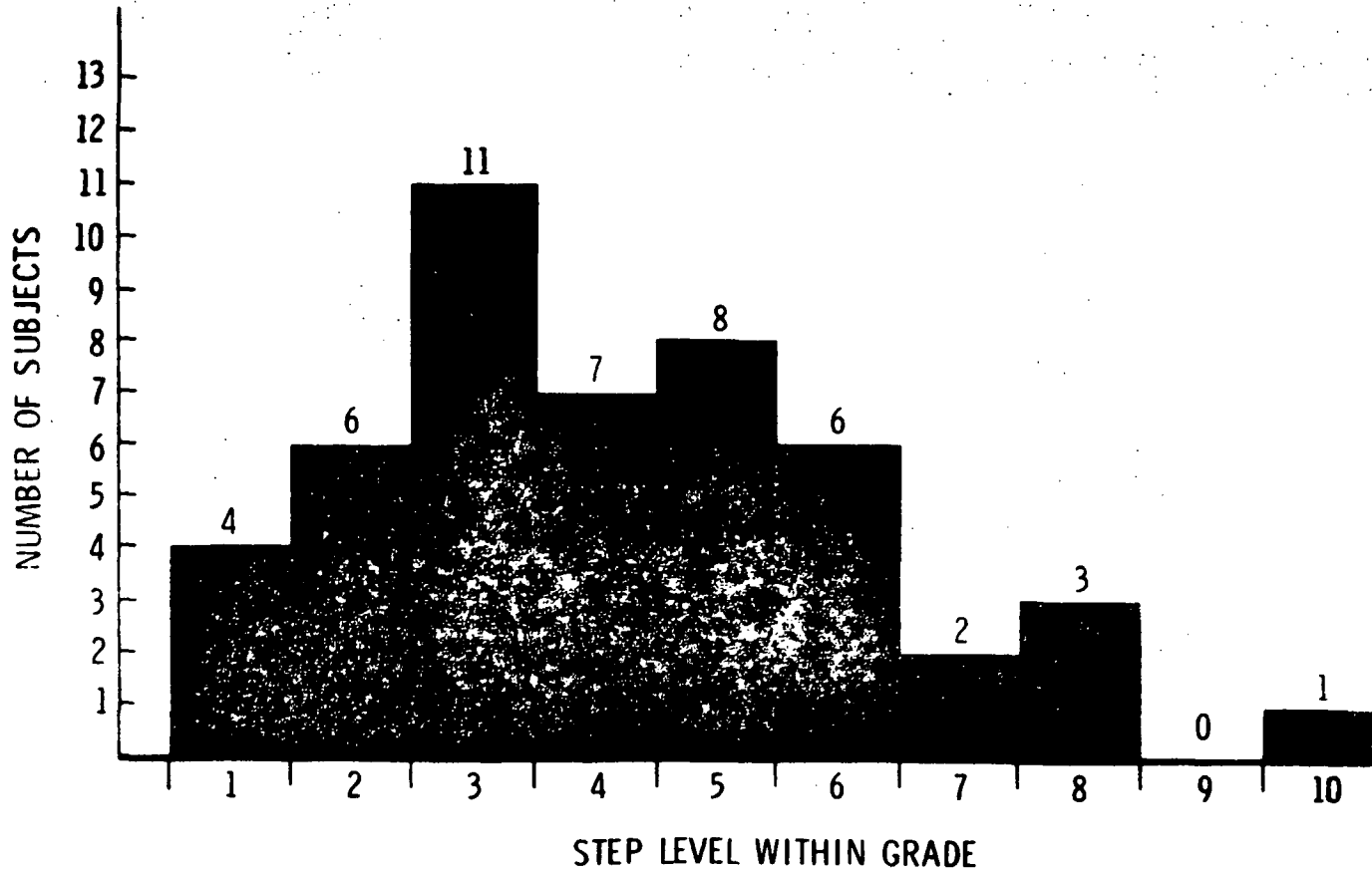


FIGURE 7: DISTRIBUTION OF SUBJECTS BY GS GRADE



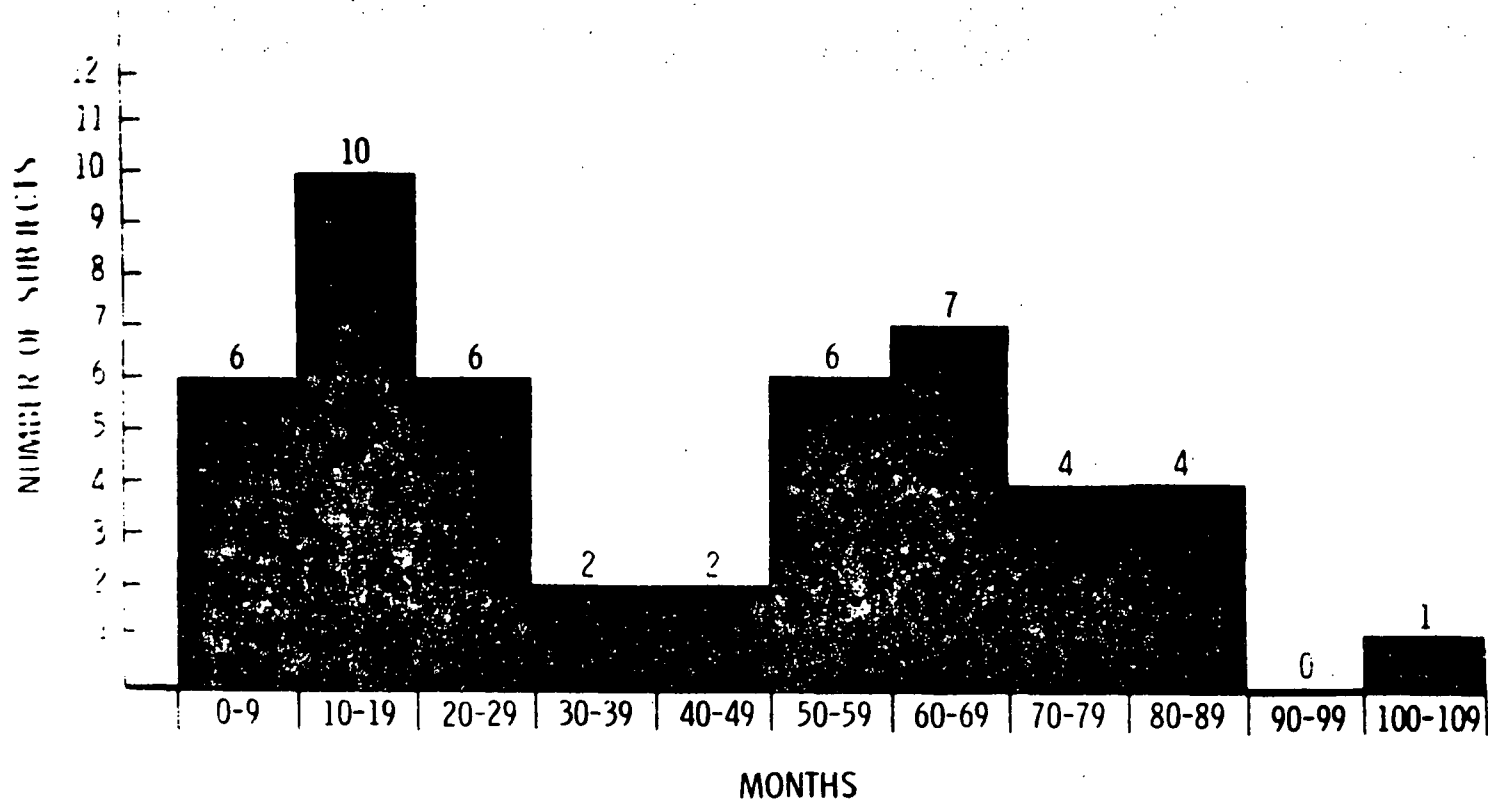
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FIGURE 8: DISTRIBUTION OF SUBJECTS BY STEP LEVEL WITHIN GRADE



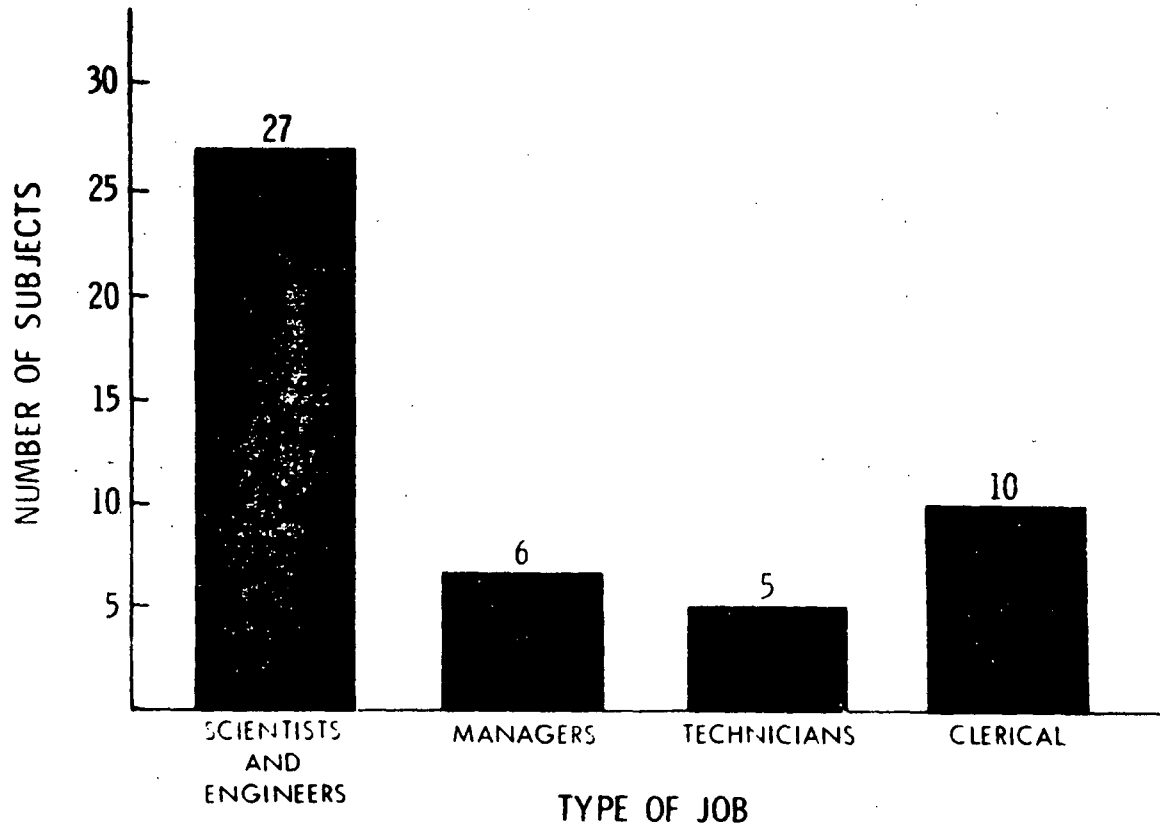
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FIGURE 9: DISTRIBUTION OF SUBJECTS BY TIME SINCE LAST PROMOTION



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FIGURE 10: DISTRIBUTION OF SUBJECTS BY TYPE OF JOB HELD



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FIGURE 11: DISTRIBUTION OF LENGTH OF TOTAL SERVICE OF THE SUBJECTS

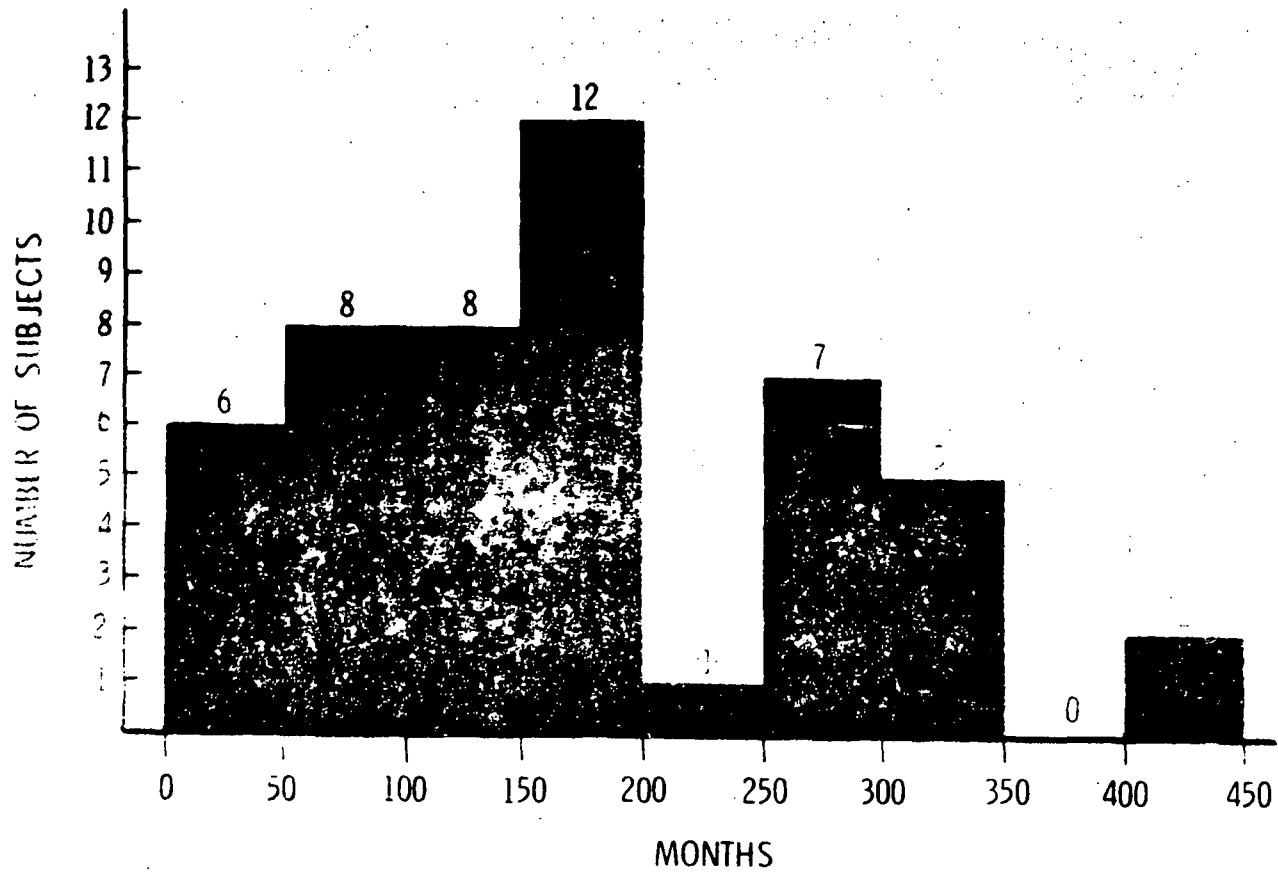
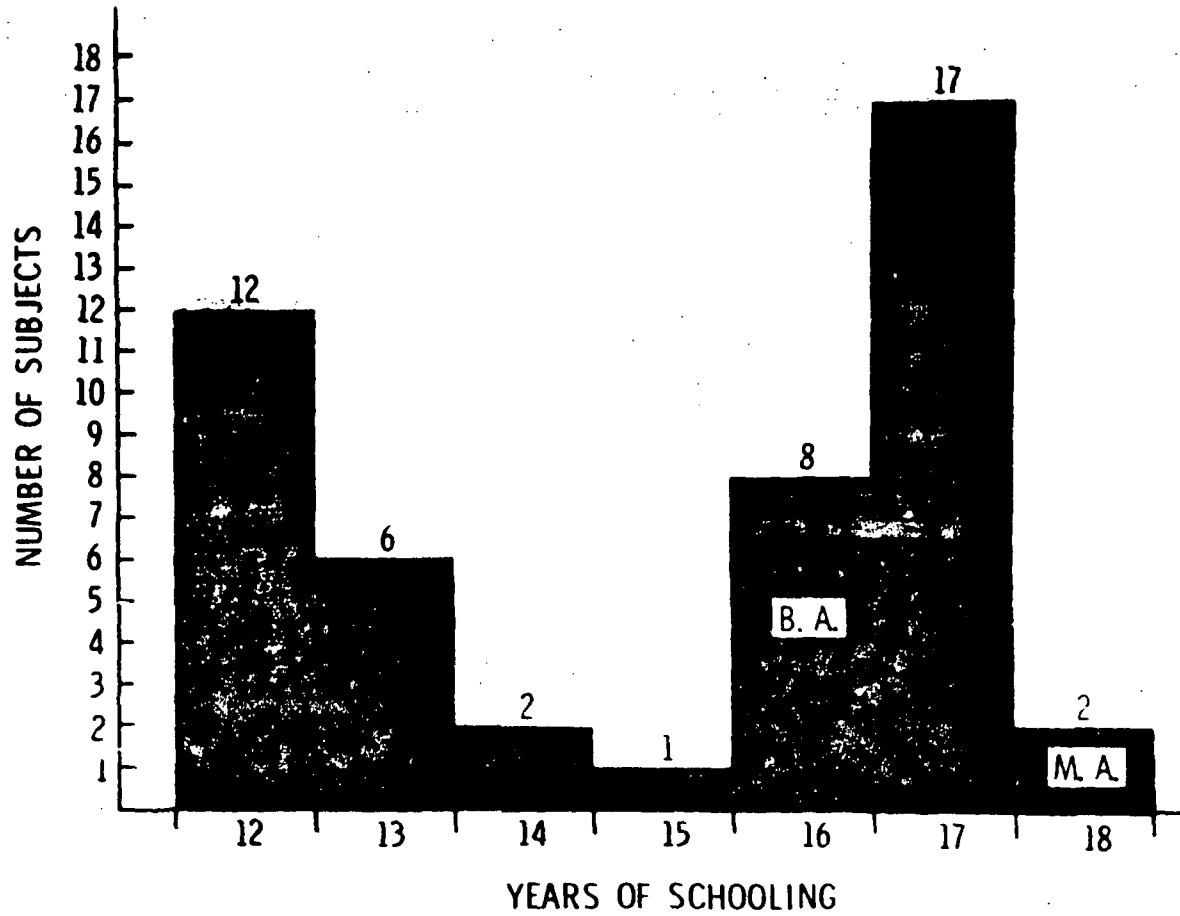
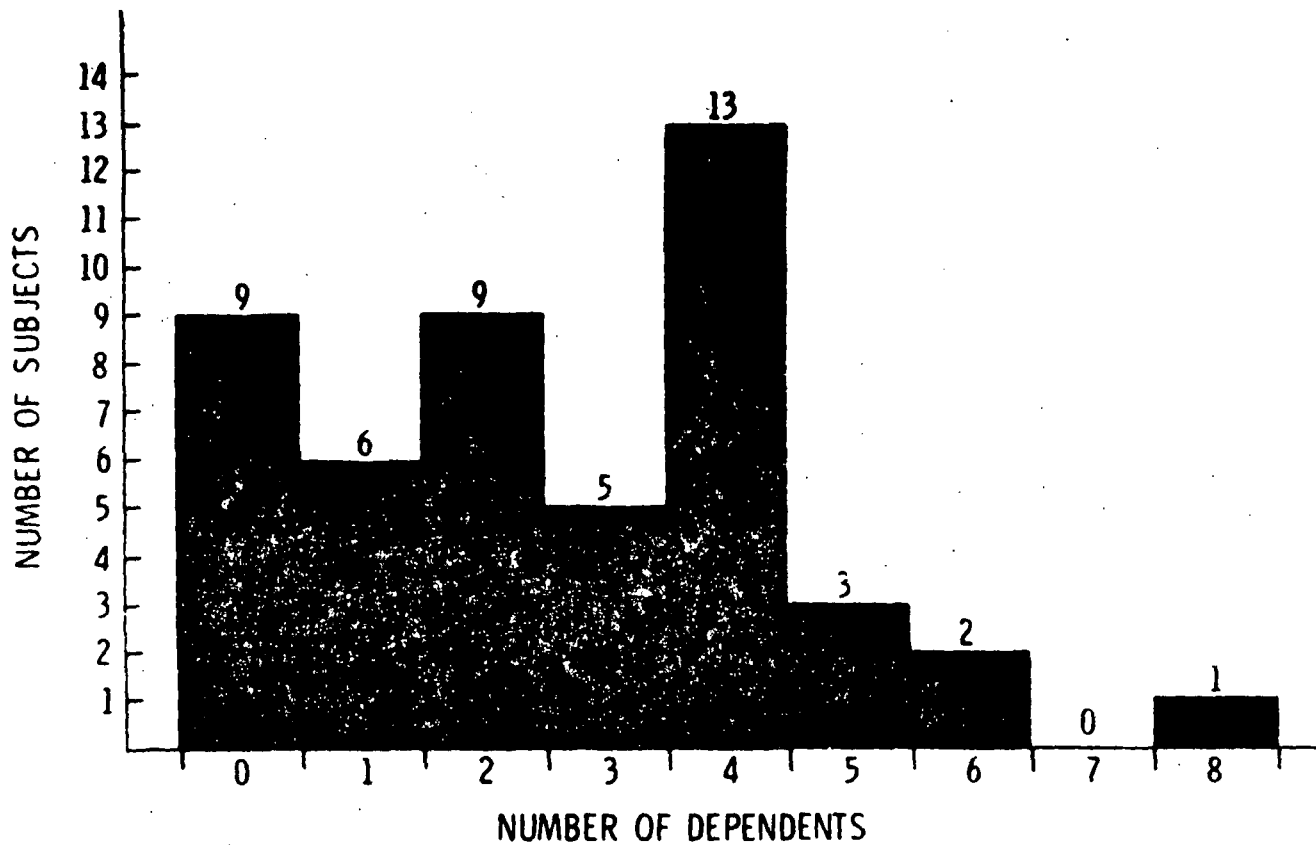


FIGURE 12: DISTRIBUTION OF SUBJECTS BY EDUCATIONAL LEVEL



**FIGURE 13: NUMBER OF DEPENDENTS
REPORTED BY SUBJECTS**



92
FIGURE 14: DISTRIBUTION OF SUBJECTS BY OFFICE ASSIGNMENT

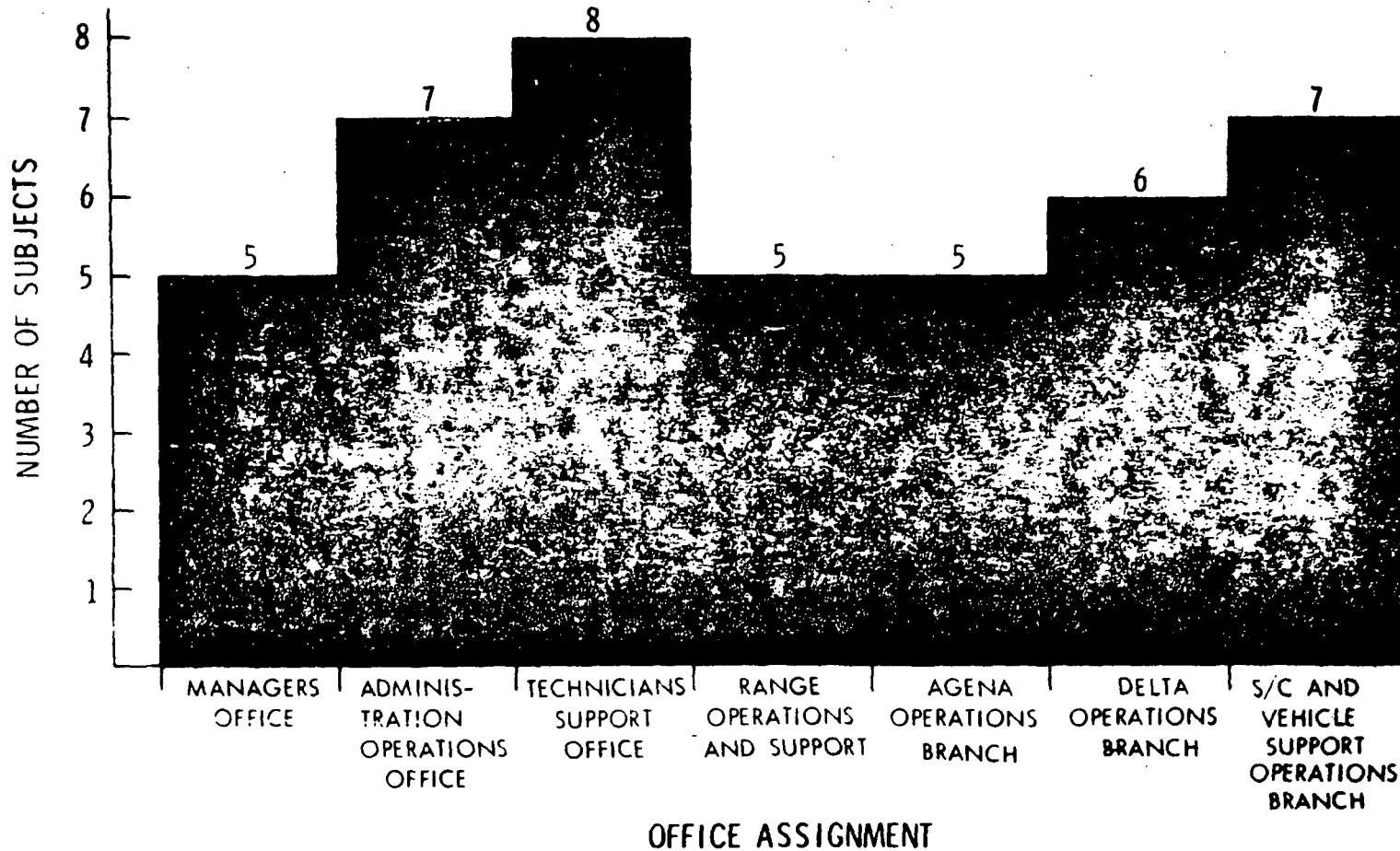


FIGURE 15: CORRELATION BETWEEN HEALTH RATINGS AND CERTAIN RELEVANT VARIABLES UNDER STUDY

	<u>HEALTH RATING</u>	<u>SIGNIFICANCE</u>
YEAR'S TOTAL COMPENSATORY LEAVE	r = .11	NS
YEAR'S TOTAL OVERTIME	-.34	S(.01)
YEAR'S TOTAL ANNUAL LEAVE	-.40	S(.01)
YEAR'S TOTAL SICK LEAVE	-.44	S(.01)
AGE	-.62	S(.01)
SEX	*	*
GS GRADE	-.22	NS
GS STEP LEVEL	.25	NS
TIME SINCE LAST PROMOTION	-.03	NS
TYPE OF JOB	.47	S(.01)
TIME WITH NASA	-.04	NS
TIME WITH FEDERAL GOVERNMENT	-.66	S(.01)
EDUCATIONAL LEVEL	*	*
OFFICE WHERE WORKING	.02	NS

* POPULATION INAPPROPRIATE FOR ANALYSIS DUE TO ALL FEMALE EMPLOYEES HAVING
BEST HEALTH, LOWEST EDUCATIONAL LEVELS, AND LOWEST LEVEL JOBS.

**FIGURE 16: OVERTIME AND LEAVE AS RELATED TO PERIODS
OF PEAK (STRESS) AND LOW (NON-STRESS)
MISSION ACTIVITY LEVELS**

<u>PAY PERIOD</u>	<u>MEAN TIME (HOURS)</u>		
	<u>OVERTIME</u>	<u>ANNUAL LEAVE</u>	<u>SICK LEAVE</u>
JUST PRIOR TO LAUNCH	14.52	2.19	.93
IMMEDIATELY POST LAUNCH	.33	8.34	1.61
INDEPENDENT OF LAUNCH	.91	7.70	2.41

Statistical significance markers:
 - A bracket between 2.19 and 8.34 is labeled S(.05).
 - A bracket between 8.34 and 7.70 is labeled S(.01).

173-17055

ENVIRONMENTAL HEALTH PROGRAM IN NASA

Rudolph M. Marrazzo
Chief, Environmental Health Branch
Division of Occupational Medicine
and Environmental Health
National Aeronautics and Space
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Washington, D. C.

I plan to talk about the organization of the Environmental Health Program in NASA; the concept of functional management, some of our operational activities; and a little discussion on our more important problem areas in environmental health.

My concept in developing an environmental health program for NASA was to address our resources to the conservation of employees health and the environment from any factor which may be a hazard. An effective environmental health program will contribute to less absenteeism from injury and illness, better productivity and effectiveness, fewer claims for bodily impairments caused by various factors in the environment and a high degree of dedication and morale. Environmental health at NASA Headquarters is located in the Division of Occupational Medicine and Environmental Health, which is located in the Office of Administration under the NASA Administrator. The NASA policy on occupational medicine and environmental health is to utilize modern medical and environmental health concepts to, (1) determine the health status of employees, (2) prevent illness and promote good health among employees, and (3) identify and control factors that affect the health of personnel and quality of environment.

In terms of responsibility, field installation directors, by directive shall implement comprehensive medical and environmental health programs. The NASA Medical Director and the Chief of Environmental Health have the agency program authority and responsibility to ensure they are carried out effectively and in conformance with our standards and guides. In the NASA concept of administration, we are referred to as functional managers. By definition, a functional manager provides centralized professional leadership in a given area of specialization or discipline, such as safety, occupational medicine, environmental health, security, budget, and so on. Functional managers are responsible for recommending policy to the administrator, implementing policy decisions through operating practices and providing the Administrator with regular appraisals of overall agency performance and quality of effort. Functional managers have the authority to establish standards,

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procedures, and operating guides; review and advise on proposed allocations of personnel, funds and other resources; participate with headquarters and field officials in the selection of key personnel; conduct surveys, and reviews for the necessary evaluation of operating practices at headquarters and in the field.

We have approximately 15 NASA installations which are spread out over the country in the United States. These installations are engaged in activities ranging from research, laboratory oriented experiments, testing and launching. The scope of the health program applies to all of these areas. This slide will give you some idea of where our centers are located. I am sure most of you are familiar with a lot of these names as they appear on the map. Starting with the Goddard Space Flight Center, working your way down through Langley, and Kennedy, Marshall, Mississippi Test Facility, Flight Research Center on the West Coast, Jet Propulsion Laboratory, the Ames Research Center in San Francisco.

Environmental health, as we define it, is an applied science which is concerned with evaluating and controlling all the physical, chemical, radiological and biological factors surrounding an individual which may place upon him physiological or psychological stresses and impairment. It is also concerned with any factor which may affect the quality of the environment. This is fairly articulate, but the idea is that we are concerned with any factor which can have an effect on the health of the personnel or the quality of the environment.

Environmental health is composed of three basic disciplines; industrial hygiene; radiological health or health physics; and environmental sanitation, which is recognizing and controlling health hazards associated with the handling and distribution of food and potable water, sewage and industrial waste disposal, air and water pollution, solid waste and the storage and application of pesticides. The NASA environmental health program interfaces closely with occupational medicine, so that it is essential that personnel identified as risk regarding environmental health hazards are periodically monitored through specific health examinations, such as audiometry, chest X-rays, liver function tests, blood analysis and eye examinations, as the case may be.

Industrial hygienists, health physicists, and sanitation specialists are utilized singly or in combinations at NASA installations, depending on the extent of activities. In addition, analytical laboratory support is either provided or obtained, depending on the requirement. Unique specialty services are often obtained from other government agencies at a minimal expense. For instance, laser hazard surveys are provided

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by the U. S. Army Environmental Hygiene Agency at no fee, except travel expenses. I'll talk a little bit more about lasers later on in my talk.

Cross utilization of installation resources is encouraged and practiced. For example, the Goddard industrial hygienist provides consulting services and periodic visits to Wallops Station which is too small to justify a full-time industrial hygienist. Outside support to our program comes to us in the way of some consultants. We have Dave Sliney from the Army Environmental Hygiene Agency who is an expert on laser safety; Dick Chamberlin from M.I.T. who is a consultant on air pollution controls and fume hood ventilation. We receive direct support from the National Academy of Sciences, centers on toxicology and hearing and vision.

How do we remain cognizant of our existing and potential hazards? Well, there are various techniques. The following slide illustrates one that has been quite effective at our Marshall Space Flight Center in Alabama. I do not think you can see this too well, but essentially what we have done here is outline some of the areas on a location map by operations - e.g., manufacturing, quality assurance, aeronautic and astro type laboratories, technical services, test support areas and so forth. What they have done here is identify some of the existing or potential hazards and, of course, on this kind of a map they can conveniently determine surveillance scheduling. Of course, if anyone is identified as a risk, the information is cycled into the medical surveillance program.

Let me give you a sampling of some of the real situations which come under our surveillance at NASA centers.* This is a class 100 clean room. The "100" refers to the number of particles per cubic feet. In general, clean rooms will control particles in the .5 micron size range and up. In this slide they are attempting to detect solvent vapor concentrations encountered in propellant component cleaning. Solvents used include freon and other fluorinated and chlorinated hydrocarbons. You can tell by the configuration that this is a laminar flow type operation. There are a bank of high efficiency air filters on the left side and the air is recirculated back through the air filters into the air space.* This slide shows an industrial hygienist operating a velometer to determine the efficiency of the typical trichloroethylene bath ventilation system. In this case, the exhaust is either slot type or, possibly, push-pull. A typical medical follow-up on a trichloroethylene bath operator would be a periodic urinary biochemistry to

*Indicates use of a slide.

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detect the toxicity. Trichloroethylene can have a narcotic effect on the central nervous system. It can also produce liver damage.* This is a large paint spray booth for painting large components. The exhaust in this case is down through the grill work on either side as you can barely see there. The painters wear face respirators while operating primarily for protection against hazards of lead, esters, resins and various ketones.

*This is a set-up for painting the Saturn I-C booster at Marshall Space Flight Center. You will notice the small paint booths at both sides of the picture. These are exhausted to prevent overspray and the painters, of course, wear respiratory protection. This is nothing more than an operation showing the application of an epoxy using disposable gloves and a face respirator. Hazards in this case can be dermatitis from contact; and irritation, headache and nausea from respired resins and chemicals.

*This is a shot of the Saturn I test engine at Marshall. This particular test produced about 122 db at 15 hertz at a distance of 1200 feet. Observation galleries are approximately 2000 feet from the test stand and well protected from the hazard. This engine produces a million and one-half pounds of thrust and, of course, you know that five are used in the Saturn vehicle. Fuel is a combination of liquid oxygen and RP-1.

For the past year or so, I've had a staff assistant whose primary responsibility is radiological health protection. This is a health physicist by the name of Robert Alexander. Mr. Alexander has visited practically every one of our NASA installations and provided assistance on the effectiveness of the existing controls and also made recommendations for improvement where needed. Mr. Alexander is currently developing a NASA radiological health handbook which will describe uniform procedures for broad control programs for the agency. He will also speak to you later on the operational aspects of the overall NASA Radiological Health Protection Program.

We do have various radar facilities which are monitored for RF and radiation hazards. I won't go into any discussion on this except to say that conventional survey instruments are used and precautions are taken to ensure exclusion from hazardous RF energy. The X-radiation hazard from power amplifier tubes are monitored with an appropriate shielded instrument. Education of operators regarding radiation hazards interlocks, and so forth, is also included.

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*This is a shot of our radar facility at Grossman, North Carolina. This picture demonstrates the case with which an individual can place his head between the antenna feed and the sub reflector. The RF intensity of this region could vary from a minimum of one and one-half watts per square centimeter to a maximum of 150 watts per square centimeter. The levels would be an order of magnitude greater than those known to produce cataracts. Precautions taken here were: (1) Installation of interlocks to prevent radiation of RF beam below a 30° elevation; installation of warning lights on the dish which are automatically illuminated when a beam is radiated; and administrative SOP's advising personnel of hazards, and providing appropriate guidance, also the installation of warning signs.

*Environmental health is a prime consideration in the operation of the Neutral Buoyancy simulator at Marshall. Now the object of this simulator is to produce weightlessness so we can simulate the orbital workshops and various tasks in space, like using various wrenches. Breathing air delivered to divers in pressure suits in the tank is passed through a filter bank which you can see in this slide. The filter bank is primarily used to remove oils, scale, carbon monoxide and other impurities. The air is sampled repeatedly down-stream of the filters for total hydrocarbons, moisture content, carbon monoxide, and several other materials. In addition, the air is constantly monitored during use for oxygen content and carbon monoxide. Concentrations of oxygen and carbon monoxide above the preset limits on the respective detectors cause the alarm to be sounded.

Air for scuba bottles, emergency breathing lines, and the decompression chamber are applied from a high pressure tube trailer which is tested for breathability prior to being placed in service. Now, our experience so far, with this air has been extremely pure, and we haven't had much trouble with it. Water from the tank is sampled and analyzed periodically for the presence of harmful bacteria or fungus which is much the same as in a swimming pool.

*At Marshall we have an industrial waste treatment area which is almost complete. This area is designed to accept all liquid waste from the industrial sewer system. By a number of treatments, including dilution, settling, evaporation, neutralization, the wastes are rendered safe for release into the Tennessee River. Samples of the effluents are collected and analyzed to assure that concentrations do not exceed preset levels. Since we are on the subject of pollution, I thought I'd spend the next few minutes on our surveillance procedures using our Manned Spacecraft Center as an example.

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This is a slide of a location map at our Manned Spacecraft Center showing the various canals and ditches which are kind of outlined in red. We have sampling points set up for our canals, waste treatment plant outfall, the various ditches, cleaning shops, and an area for air particulates. Essentially what we are doing is selecting various sampling areas, and taking samples on a two week basis out of these canals and ditches and analyzing them in the laboratory. This is a shot of one of the industrial hygienists taking a sample out of the inlet canal coming from the Houston Lighting and Power Company containing cooling water. Actually this canal, by some geographic quirk, runs through the Manned Spacecraft Center. *This is also another one of the ditches or drainage areas that run through the Center where samples are collected. These samples are taken back to our laboratory and analyzed for BOD, solids, pH, phosphates, sulfates and chlorides. *This is a shot of the industrial hygienist checking the chlorine level at the waste treatment plant outfall. *This is a sampling device set up at the plating shop effluent. Here again this sample is checked for cyanides, chromium, pH; these are all done on a two week basis. *This is what we use for checking the community air at the installation. It is a high volume sampler with a fiberglass filter. It is run on a 24 hour test every two weeks; primarily checking for particulates. This is another shot of the sampler as it is being set up.

These are some shots of our environmental health laboratory at Houston. The procedures shown in these slides are:

- *1. Determining suspended solids in water
- *2. Visual titration analysis
- *3. Determining pH
- *4. Air analysis via chromatography
- *5. Water analysis via atomic absorption
- *6. Interpretation of infrared spectro photometric scan
- *7. Bacterial colony counting

In addition, a large portion of this laboratory effort is directed to the spacecraft sanitation support under the space medicine directorate.

The following slides will show you some of the elements connected with our pest control program at the Lewis Research Center in Cleveland. This is a shot of the area as it is secured for the storage of pesticides and our equipment. *This is just a shot showing some of the safety signs that are used during spray operations. *This is a picture of the inside of our pesticide storage van.

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*This shows the operators fixing the various pesticides. Putting the pesticides into the sprayer. *Here is a spraying operation of methoxychlor for adult mosquito control at the Center. *Notice the protective equipment, gloves and respirators. *Here is a shot of the operator applying a herbicide for broad leaf control at the Center. *This is a shot of the elaborate cleaning operation after the spraying. *Also, cleaning the protective clothing. *All operators are required to shower at the conclusion of our operations.

I'll talk a bit more about pest control a little later on, since we think pesticides are one of our special problems. I want to tell you about some steps we have taken to make sure we have a good effective program.

I would like to discuss some of our special environmental health programs at NASA and how we come to grips with them. I'll start with lasers. Laser, as you probably all know, is an acronym for light amplification by simulated emission of radiation. Within NASA there are approximately 300 lasers in operation. In case you are interested, we have something like 30 at Marshall, 50 at Langley, 40 at Electronics Research Center, 40 at Ames, 60 at Goddard, 30 at Jet Propulsion Laboratory and on down the line. Laser operations are mainly in four general areas: Space communications; optical radar; industrial applications; and tracking, and navigation. The primary hazards to the body appears to be the human eye, since the cornea and lens of the eye focus the laser beam on the retina and in so doing, concentrate the energy several times. Now this can produce retinal burns and lesions which can permanently impair vision. Personnel exposed to laser beams are furnished suitable protective eye wear of optical density adequate for the energy involved. *This is a picture of a laser goggle. Optical density is ten used at 6943 angstroms. This happens to be used for the ruby laser. Now, one of the things that we notice in our visits to NASA installations is that these glasses get intermixed and often the operator is not wearing the glasses with the right optical density and is not only unprotected but may very well take the unnecessary risks in viewing the direct or reflected beam. *This is a shot of an argon gas laser. You can see how you can complicate the hazard from the beam which can be redirected by the use of prisms. Of course, the redirected beam is just as hazardous as when it exits from the laser. So, these are some of the things you have to be careful about in your man/machine relationship. Another thing, too, you have to be careful about, is the various spectral surfaces you may have in the area of your operation. Because, here again, the reflected beam can be just as serious a hazard as the beam from the laser itself.

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*This just shows the internationally accepted symbol for the laser hazard.

Medical surveillance, generally, includes a preplacement eye examination, including a retinal photograph. Periodic eye examinations can then be compared to this baseline for pathological observation, as well as evidence in court cases involving claims against the government. Recognizing our limited resources, our approach to the potential laser hazard at NASA was to enlist the support of some nationally recognized experts who truly understood the laser hazard and could evaluate each operation from the concept of a man/machine system. The Army Environmental Hygiene Agency at Edgewood Arsenal appeared to have excellent credentials along this line, and in particular, an outstanding young physicist by the name of Dave Sliney, who was enlisted as a consultant of our program. Mr. Sliney, at our invitation, conducted surveys at our Manned Spacecraft Center, Marshall, Goddard, Ames Research Center, Langley, and Lewis. Mr. Sliney's report, impacts primarily on hazard conditions and recommendations for each laser operation. In addition, guidance is offered on the basic precaution, looking into the beam, and expected reflections. This should be avoided, of course. His report also contains criteria for selecting appropriate eye wear. We have just prepared a NASA standard on the control of health hazards from laser radiation and this should be published in the next month or so. A couple of the important features in this standard are that we are requiring registration of all lasers with our environmental health department at NASA installations; secondly, there will be a preoperation approval and certification required by environmental health officials.

Another item that has been emerging as a concern for health hazards are microwave ovens. Microwave ovens are used primarily for rapid heating and cooking of foods. Electromagnetic radiation of this type may be harmful to some parts of the human body, such as the eyes, if exposed to radiation levels significantly in excess of the recommended threshold levels of 10 milliwatts per square centimeter. About a year ago, we alerted NASA installations to this potential hazard and recommended that all microwave ovens be surveyed periodically for radiation leakage. Overall count of these ovens in NASA is approximately 75. Our experience has been that approximately 20 percent of these ovens have, at one time or another, exceeded the permissible exposure level. Primary reason for leakage has usually been defective door gaskets, hinges and latches.

Most of these ovens have been provided through vendors who have been very cooperative in repairing or replacing ovens as required. For

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the most part, these ovens are now surveyed on the basis of once every two months. We feel that the potential microwave oven hazard is under good control in NASA. One area that needs improving is the notification problem between the parties responsible for putting the ovens in service and health officials responsible for hazard surveillance. Steps are being taken to eliminate this problem with an agency standard on the subject of microwave ovens which is in preparation at this time.

The other subject I mentioned earlier is that of pesticides. We are obviously concerned about this, not only from the standpoint of hazards as it presents itself to people, but also from the pollution aspect. Pesticides are chemical substances used to kill pests. Pests may be weeds, insects, rats, mice, algae, worms and any other destructive form of life. Improperly used, poisonous pesticides can and do cause illness, even death, to human beings. Within NASA, every installation has some form of a pesticide control program with the exception of Electronics Research Center and NASA Headquarters which rely on another government activity. The majority of these programs are executed through contractors, like professional exterminators. We ask each NASA installation on an annual basis to report on their upcoming pesticide activities, highlighting the objective, pesticides to be used, rate of application and method of application. Now these data, once compiled, are referred to the Federal Committee on Pest Control, with whom we meet annually to review the total program to correct any problems before they occur. This year, we have asked for specific guidance on the continued use of DDT and other hard pesticides. We have advised our installations to substitute something less toxic where possible. In addition, we encourage all centers to contact us on any special problems as they arise. Our environmental health personnel at the installation concern themselves with storage, application and handling of pesticides, as well as periodic physical examinations.

Another problem area that we looked at very carefully has to do with beryllium. We do have some industrial operations within NASA involving beryllium. As you know, beryllium is an extremely desirable metal because of its light weight, durability, and heat resistance. The machining operations at Marshall is the largest industrial facility in NASA. Industrial hygiene controls in effect are considered very effective. These chips and particles, as you can see, are captured at the point of generation and passed through a high efficiency filter before the air is exhausted to the outside. Protective clothing is provided to employees and laundered separately on the premises. Air samples are taken in-plant and off-plant at periodic intervals and the

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air filters are buried at a remote site. The TLV for beryllium (in plant) or two micrograms per cubic meter and (off plant) .01 micrograms per cubic meter are strictly observed.

*At this particular facility, we have six people working there. Beryllium takes up less than 50 percent of the facility activity and we have a laundry located at the facility, as I mentioned earlier. *The ventilation is of a high velocity, low volume type. The air samples, as they are collected, are referred to an analytical laboratory at Marshall for spectrographic analysis and the waste filter is packed in an airtight polyethylene bag and buried in a sanitary fill. This appears to be a preferred method of disposal at this time. There are not enough beryllium chips in the filters to make reclamation economical. These machine workers get medical lab tests, blood, urine, and chest X-rays every six months and, in addition, an annual physical exam. Now, another application of beryllium at NASA is in the area of propellant additives. The use of beryllium in rocket motor fuel offers a significant increase in performance and is thereby being explored for upper stage use. Our role is to provide advice to the NASA project office on the industrial hygiene and medical considerations. Just recently, a 3000 pound, ten percent beryllium motor was test-fired by a NASA contractor on the Air Force Western Test Range Facility at Eniwetok. Preliminary results indicated that all criteria, such as air quantity, surface contamination, and soil content were satisfied.

Some of the basic guides that we provide are: (1) Concern must be exercised for the protection of people; the prevention of pollution to the surface and ground water or soil; damage to plant life and harm to animals. (2) From the standpoint of background data, analyses should be made of prefiring and postfiring soil samples for beryllium concentrations at the points of air sampling. The prefiring sampling should be taken at the time air samples are activated and the post-firing samples taken at the time the air samples are picked up. This pick-up must not be made before the entire cloud has passed by and settling out has stopped. (3) In-plant, atmospheric beryllium levels should not exceed two micrograms per cubic meter as I mentioned earlier, time-weighted on a daily basis. Off-plant or neighborhood concentrations at the breathing zone level should not exceed .01 microgram per cubic meter checked on a daily basis. In the prediction formula for computing downwind exclusion radii for beryllium propellant combustion cloud, the latest Public Health Service air quality criteria of 75 microgram minutes per cubic meter within the limits of 10 to 60 minutes must be used. Surface contamination shall not exceed 25 micrograms beryllium per square foot and soil contamination levels shall be set at 100 micrograms

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beryllium per gram of soil. Where personal respiratory protection is required, it is recommended that the MSA Comfo with Type H filter or something comparable be used. These respirators should be worn in required areas during the operation until it is established that the TLV level has not been exceeded. Other criteria covers the selection of high volume samplers, filters, analytical requirements, breathing zone samplers and medical monitoring.

If I can leave those topics for a minute, I would like to talk for just a few minutes about an important dimension to our NASA safety and health program in the area of application of NASA contractors. The NASA procurement regulations contain a recently updated directive which covers safety and health as referred to in subpart 52. This subpart sets forth the policy, responsibility, and requirements related to NASA safety and health programs with regard to its contractors. It is NASA's policy that contractors and subcontractors undertake performance of the safety and health conscious environment which, within the limits of controllable hazards, will; protect the life, health and physical well-being of NASA contractor employees doing their work on NASA programs; assure proper protection to the public; avoid accidental work interruptions; prevent contamination of property, supplies and equipment; and provide data whereby risks and loss factors in space technology related to the programs can be accumulated and evaluated. It is basically the responsibility of the originator of a NASA procurement request to determine to what extent a contractor safety and health plan will be required. He does this on the nature of the procurement and by conferring with appropriate safety and health officials at the installation. Safety and health officials will advise the contractor in; determining to what extent safety and health provisions, if any, should be included in the proposed procurement; electing the specific safety and health provisions to be included in the contract schedule; determining adequacy of contractor safety and health plans; and determining the extent and form of accident/incident reports. The contracting officer will obtain the advice, assistance, and recommendations of the safety and health officers prior to the issuance of an invitation to bid or request for proposal in the following procurements; booster and engines, transportation of fuels, oxidizers and other hazardous materials; research, development, or test of engines; operations which involve health hazards or the use of a hazardous material, including potential contamination to property, pollution of air, water, vegetation, soil; and adverse alteration of the work environment by activities concerned with ionizing radiation, microwave, noise, lasers, and any other direct or secondary effect.

The clause may be excluded from any contract which is subject to either the Walsh-Healey Public Contracts Act or the Services Act of 1965 in which the application of either act constitutes adequate safety and health protection. Basically, the clause has provisions for a safety and health

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plan to be submitted for the contracting officer's approval; reporting of accidents and incidents; non-compliance notification of stop work when required; application of the clause on subcontractors and suppliers; and finally, the authorization of NASA representatives to examine contractor work sites for adequacy of safety and health measures.

This updated clause has been in effect about two or three months. Some of our recent visits to the centers indicate that it is working. We know that some of our people have been meeting with the contracting officers determining where we need some special information in the contract schedule which is not covered by the Walsh-Healey Act.

I will close this presentation by showing a short film (10 minutes) on the subject of environmental health which was produced by Charles McHenry, Industrial Hygienist at Xerox Corporation. This film has been very useful in presenting the environmental health program to management in a very meaningful and productive manner.

N73-17054

ENVIRONMENTAL HEALTH PROGRAM ACTIVITIES - MSC

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Occupational Medicine Program Officer
NASA Manned Spacecraft Center

The Kelsey-Seybold Clinic of Houston, Texas, is responsible for our Medical Support Services Contract. We have just begun the second three-year period with their personnel and expect it to be the best to date, having had three prior years of experience.

There is presently a full staff complement of 50 to cover six rather diversified program areas:

Occupational Medicine

Occupational Medicine Dispensary
Medical Operations Testing Support
Cardiopulmonary Laboratory

Environmental Health

Industrial Hygiene
Spacecraft Sanitation
Radiological Health

I will now speak more directly to the Environmental Health portion:

Industrial Hygiene

A condensed summary of industrial hygiene activities for the contract year, October 1, 1968, through September 30, 1969, includes the following. Investigations, including detailed studies, of reported hazardous conditions comprised a total of 219 field visits, of which 63 were self-initiated. Examples of items investigated are toxic air-contaminants, excessive noise, poor lighting, food sanitation, water pollution, and exposure to nonionizing radiation such as microwave and ultraviolet light. A total of 1,295 field determinations were made and 1,065 samples were submitted for laboratory analysis. Advisory services are provided for the preparation of criteria, designs, and specifications for facilities where toxic or potentially health hazardous agents are involved.

Several special projects were accomplished. Examples of such projects include the following: Talks were prepared and presented for the Basic Radiological Health Course given at Ellington Air Force Base; for the

Industrial Medical Association Seminar held at the downtown Kelsey-Seybold Clinic, and the Educational Conference of the National Association of Sanitarians; a one-hour training course regarding mercury hazards was prepared and sessions presented; health hazard bulletins were completed on beryllium, benzene, carbon monoxide, formaldehyde, propellants and oxidizers, cross-connections, and sulfur dioxide; a written procedure for collecting "Type B" breathing air samples was prepared; a proposed MSCI Management Instruction entitled "Laser Hazards - Policies and Procedures for Personnel Protection" was developed and submitted for review and comment.

Members of the staff attended a number of professional activities including a variety of short courses. Included were the annual Industrial Hygiene Conference held in Denver, Colorado; a Sanitarian's Seminar held in Fort Worth, Texas; a short course in Advanced Methods for Water-Pollution Analysis given at the University of Houston; and a short course on Pesticides and Public Health given at the Communicable Disease Center of the U. S. Public Health Service. It is felt that these and the other professional activities attended were of significant value to our industrial hygiene program.

Radiological Health

The Health Physics' staff was requested to provide the Radiological Safety Officer for MSC under terms of their NASA contract.

A radiological health manual for MSC operation was prepared and presented to the MSC Radiation Safety Committee and various interested individuals for comment. After incorporation of the comments received, the manual was approved by the MSC Radiation Safety Committee and the Director of Medical Research and Operations, to provide guidance to personnel, both NASA and contractor, in the procurement and safe handling of radioactive material or radiation producing equipment at MSC.

Employee development was stressed in the Health Physics staff during the past year. Some of the formal training received by members of the staff was the USPHS courses, "Basic Radiological Health," "Occupational Radiation Protection," and "Accelerator Radiation Protection."

Effort in Space Radiation Dosimetry, supporting the Radiological Health Team, commenced in May 1969. It is the goal of Space Radiation Dosimetry to evaluate radiation exposures to astronauts in light of medical responses which may influence the general well-being of the flight crew or the ultimate success of a manned spacecraft mission.

Activities to date in Space Radiation Dosimetry have fallen in three basic categories: pre-mission planning and dose estimation, real-time dosimetry at the Space Environment Console, and postflight dose evaluation. Real-time support was given during the Apollo 10 and 11 missions. Radiation dose to the crews of these missions was nominal and medically insignificant. Postflight evaluations of these missions did uncover a number of shortcomings in dosimetry techniques, however. As a result, a new dosimeter system (for neutron detection), has been designed by Space Radiation Dosimetry and will be flown on Apollo 12. A portion of the neutron system was tested on Apollo 11.

Spacecraft Sanitation

The spacecraft sanitation function was incorporated into the contract on October 1, 1968, with the responsibility for accomplishing spacecraft potable water and waste management and personal hygiene support.

During the report period, Apollo 7 through 11 manned spaceflights, and altitude chamber tests in support of the missions were documented. In an effort to obtain information regarding the significance of microbiological and chemical analyses of spacecraft potable water, considerable time was spent searching literature pertinent to the Apollo program. A similar effort was conducted with regard to potential or anticipated problems connected with Apollo Applications and Advanced Mission Programs. These problems involve the use of additives, such as corrosion inhibitors, trace metallic ions, and bactericidal agents. A study was initiated on "Closed Ecological Systems" in anticipation of future research efforts in potable water and waste management and personal hygiene. The Apollo Water Sampling Device was developed and tested in support of preflight and postflight potable water collection from the spacecraft.

A major part of the overall goal was the development of a water analysis laboratory, an essential adjunct to the success of the effort. Monitoring of the chemical and microbiological quality of the potable water for manned space flights and altitude chamber tests will be conducted by the laboratory. The laboratory will contribute to future research efforts in Spacecraft Sanitation.

The last section is the Environmental Health Services Laboratory which was designed to function primarily in the areas of industrial hygiene and spacecraft sanitation, and as such, has assumed responsibilities for developing, evaluating, coordinating, and documenting test and

sampling procedures for the analytical chemistry and microbial analyses of air, water, food, drugs, and biological specimens. More specifically, the laboratory is monitoring adulteration and pollution of air and water by means of physical, chemical, and microbial analyses.

During the past year, the laboratory has been in the process of being remodeled to provide additional space for the following instruments which have been received and will be installed upon completion of the construction work: infrared spectrophotometer, atomic absorption spectrophotometer, ultraviolet and visible spectrophotometer, refractometer, tensiometer, conductivity monitor, Super-Q water system (Millipore), and semi-micro analytical balance. The instrumentation mentioned here is in addition to the gas chromatograph which was acquired approximately a year earlier. Although many of the procedures for the analyses are outlined in U. S. Public Health and/or NASA specifications, the ability to up-date and expand these and other analytical techniques will be emphasized in the operation of the laboratory.

N73-17057

THE RELATIONSHIP OF NASA OCCUPATIONAL MEDICINE
AND ENVIRONMENTAL HEALTH WITH THE ADVISORY CENTER
ON TOXICOLOGY

Ralph C. Wands
Director, Advisory Center on Toxicology
National Research Council
National Academy of Sciences

The Advisory Center on Toxicology is a part of the National Academy of Sciences. The Academy was organized in 1863 under a Congressional Charter which was signed by President Lincoln, and one of the main functions of the Academy was to provide a pool of the nation's scientific and technical manpower that would be available on request to provide consultation to the Federal government. This is still one of the major roles of the Academy and over the years the organization has been expanded to provide for an increasing involvement in Federal scientific and technical problems. In 1947 the Academy established a Committee on Toxicology which primarily served the Armed Forces and the Atomic Energy Commission. After ten years of operation the workload on this Committee had grown to such an extent that they needed full-time professional staff support which resulted in the formation of the Advisory Center on Toxicology in 1957. Administratively, the Center is placed under the Division of Chemistry and Chemical Technology of the National Research Council; however, it also operates in close consultation with the Division of Biology and Agriculture and the Division of Medical Sciences.

The Advisory Center on Toxicology maintains thorough coverage of the technical literature in toxicology and allied subjects. Its present holdings include approximately 2,000 textbooks, 12,000 reprints, and many years' collection of technical journals and abstract bulletins. In addition, there is an extensive collection of government bulletins and laboratory reports as well as unpublished information supplied by private industry. All of the pertinent information in this collection is thoroughly cross-indexed so that it may be rapidly retrieved when needed. There are approximately 200,000 index cards in the collection and it is estimated that there are entries on nearly 50,000 chemical compounds. The staff of the Center consists of less than 10 people including two professional scientists. They are able to call upon the Committee on Toxicology for any necessary help in providing service to the sponsors. The membership of the Committee changes from time to time and its members are always appointed from the best people in the field from government, academic institutions, and private industry. The present membership of the Committee is shown in the accompanying list and represents a variety of professional specialties and an impressive collection of experience. Each of these members serve out of a sense of professional responsibility and patriotic duty, and they serve without any fees or

honoraria, but are reimbursed for their out-of-pocket travel expenses associated with the work of the Committee.

The list of Committee members also shows the various federal agencies who are fiscal sponsors of the Center and Committee, and for whom the bulk of the work is accomplished. Within the NASA organization funds are annually appropriated in support of the Center by the Office of Research and Technology under Dr. Walton L. Jones. The Center maintains technical liaison not only with Dr. Jones' office, but also with the Division of Occupational Medicine and Environmental Health under Dr. Arnoldi and Mr. Marrazzo. In addition, technical liaison has recently been established with General Humphrey's office and with Dr. Orr Reynolds' group on space biology. The services of the Center and the Committee are available to the entire NASA organization including their contractors by communication to and from these technical liaison representatives. Mr. Marrazzo has been serving as the Liaison Representative for the Division of Occupational Medicine and Environmental Health, and requests for assistance from the various field operations under this Division should be routed through him. Mr. Marrazzo and the Center fully recognize that occasionally it is necessary to obtain information and guidance rapidly, in which case, we are quite willing to receive requests by telephone, and ask only that the communication be confirmed later in writing in order that the records may be kept straight.

The actual services of the Center and Committee are perhaps best described by identifying things which are excluded and by giving some examples of things which are included. The Center does not concern itself with problems of the toxicity or adverse reactions of drugs and other pharmaceuticals. When such problems do come to the Center, the advice and assistance of the Food and Drug Administration is obtained. The general business of forensic toxicology is not covered by the Center, nor is much attention given to analytical procedures associated with toxicity studies. The Center is becoming increasingly involved in the toxicity of pesticides; however, it is not deeply involved in the current questions of contamination of our environment and food supplies by pesticides. At the same time, there is a fairly extensive involvement in matters of air pollution arising from the sponsorship by the National Air Pollution Control Administration. The Center has only occasionally dealt with questions of water quality

and these have always had direct relationship to the interests of the sponsors. For example, assistance was given NASA in establishing criteria for the quality of the drinking water of the astronauts during the Gemini and Apollo programs.

The main area of coverage by the Center might thus be identified as the toxicology of commercial products. For example, there has been a continuing and close relationship with Dr. Harris of Houston on the off-gassing of materials of construction of spacecraft with the resulting contamination of the atmosphere within the craft. A recent example of this type of activity was the assistance provided to the Biosattelite III program. During the course of a pre-flight check, the highly instrumented monkey in the craft became seriously ill and later died before the pre-flight check could be completed. The Center was able to identify the toxic component being generated in the spacecraft and to suggest its source. The contaminant was dichloroacetylene which is an extremely toxic gas that has been encountered in a variety of closed environments. This gas is formed by the chemical decomposition of chlorinated hydrocarbon solvents passing over alkaline carbon dioxide scrubbers. There have been some human fatalities attributed to this gas and it can produce serious symptomatology upon prolonged exposure to just a few parts per million. If chlorinated hydrocarbons have been used as cleaning solvents or non-flammable solvents in adhesives during the construction of the closed environment, there may be sufficient off-gassing to be converted to a dangerous atmosphere.

One of the unique services provided by the Committee on Toxicology with the assistance of the Center is the recommendation of Emergency Exposure Limits for military and space chemicals. Accidental spills and exposures to materials having a high acute toxicity can always occur, and the Committee provides guidance to medical and engineering management personnel in the form of these EEL's which permits planning to minimize the injury potential of such emergencies. A list of the Committee's present recommendations is attached and each of these has been developed by the Committee in response to a specific request from one of the sponsoring agencies, frequently for a very special set of circumstances. These recommendations should not be applied to other circumstances without first checking to be sure that they are indeed applicable. In recommending these levels the Committee has made several assumptions including the following:

a. Since these are emergencies, an individual is only likely to be exposed once during a lifetime.

b. During the emergency an exposed individual will have to take some immediate action which may include control of the emergency or personal escape.

c. Under such circumstances, some degree of injury or effect upon the individual may be tolerated provided such effect does not interfere with the required action during the emergency and does not produce irreversible injury to the individual. It is hoped that personnel will never be exposed to these limits and certainly operations should be conducted in such a way that only essential personnel will be placed where such emergencies can arise. In particular, these limits are not to be applied to exposures of the general public to atmospheric contaminants. It will be noted that some of the recommended limits are tentative, and this situation arises from the fact that there are not sufficient data upon which to make a firm recommendation; however, in view of the pressing need of the requesting agency, the Committee has exerted its best judgment and made these tentative recommendations pending the collection of adequate data from research.

It can be concluded from these examples that the main efforts of the Committee and of the Center are oriented toward preventive measures of occupational medicine and industrial hygiene rather than post facto treatment. An additional function is that of research coordination among the various sponsoring agencies in order to promote efficient attack upon common problems and rapid distribution of information of common interest.

ADVISORY CENTER ON TOXICOLOGY

Operates jointly under the Divisions of Chemistry and Chemical Technology, Biology and Agriculture, and Medical Sciences.

Director of Center, Ralph C. Wands, National Research Council.

COMMITTEE ON TOXICOLOGY

Chairman, Dr. Herbert E. Stokinger, Chief, Laboratory of Toxicology and Pathology, Bureau of Occupational Safety and Health, Consumer Protection and Environmental Health Service, Environmental Control Administration, Cincinnati, Ohio (1971)

Vice-Chairman, Seymour L. Friess, Director, Physiological Sciences Dept., Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md. (1971)

Bertram D. Dinman, M. D., D. Sc., Acting Director, Institute of Industrial Health, The Medical Center, University of Michigan, Ann Arbor, Mich. (1971)

Arthur B. DuBois, M. D., Department of Physiology, Division of Graduate Medicine, University of Pennsylvania, Philadelphia, Pennsylvania (1971)

R. E. Eckardt, Director, Medical Research Division, Esso Research and Engineering Company, Linden, New Jersey (1971)

Arnold J. Lehman, M. D., Pharmacological Research Advisor, Bureau of Scientific Research, Food and Drug Administration, Washington (1970)

Harold M. Peck, M. D., Senior Director of Safety Assessment, Merck Institute for Therapeutic Research, West Point, Pennsylvania (1971)

V. K. Rowe, Biochemical Research Laboratory, The Dow Chemical Company, Midland, Michigan (1970)

C. Boyd Shaffer, Director of Toxicology, American Cyanamid Company, Wayne, New Jersey (1971)

Henry F. Smyth, Jr., Ph. D., Professor of Applied Toxicology, University of Pittsburgh Graduate School of Public Health, Pittsburgh, Pennsylvania (1970)

SPONSORS

Departments of the Air Force, Army, Coast Guard, and Navy, the Atomic Energy Commission, Federal Aviation Administration, Department of Agriculture, National Air Pollution Control Administration, and the National Aeronautics and Space Administration.

October 1969

EEL's RECOMMENDED BY NAS-NAE/NRC COMMITTEE ON TOXICOLOGY

	<u>10 Min.</u>	<u>30 Min.</u>	<u>60 Min.</u>
Acrolein			0.2 ppm
Aluminum fluoride	25 mg/m ³	10 mg/m ³	7 mg/m ³
Aluminum oxide	50 "	25 "	15 "
Ammonia (anhydrous)	500 ppm	300 ppm	300 ppm
Boron trifluoride	10	5	2
*Bromine pentafluoride	3	1.5	0.5
Carbon disulfide	200	100	50
Carbon monoxide (normal activity)	1500	800	400
(mental acuity)	1000	500	200
*Chlorine pentafluoride	3	1.5	0.5
Chlorine trifluoride	7	3	1
Diborane	10	5	2
1,1-Dimethylhydrazine	100	50	30
Ethylene oxide	650	400	250
Fluorine	15	10	5
*Formaldehyde			3
Hydrazine	30	20	10
Hydrogen chloride	30	20	10
Hydrogen fluoride	20	10	8
Hydrogen sulfide	200	100	50
*JP-5	5 mg/L.	5 mg/L.	2.5 mg/L.
*Monomethylhydrazine(MMH)	90 ppm	30 ppm	15 ppm
Nitrogen dioxide	30	20	10
Oxygen difluoride	0.5	0.2	0.1
Perchloryl fluoride	50	20	10
Sulfur dioxide	30	20	10
Sulfuric acid	5 mg/m ³	2 mg/m ³	1 mg/m ³
Tellurium hexafluoride	1 ppm	0.4 ppm	0.2 ppm
1,1,2-Trichloro-1,2,2-trifluoroethane (Refrigerant 113)			1500 ppm

*Tentative

N73-17058

MACHINING OF LOW PERCENTAGE BERYLLIUM COPPER ALLOYS

by John G. Habermeyer
Safety Officer - Ames Research Center

Last year while talking with the Safety Director of a large corporation, I asked how they handled the machining of low percentage beryllium alloys. He explained they handled all their beryllium alloys in their controlled machine facilities. However, occasionally they received information that some machining of the low percentage alloys had or was being performed in one of the non-controlled shop areas. I inquired whether they had ever taken breathing zone samples during the machining of these low percentage alloys. He said no, in fact on a few occasions they had rushed out to one of the non-controlled areas to take air samples but the job mysteriously disappeared.

Earlier this year I received word that our machine branch was going to do some machining of a two percent beryllium alloy. I decided this was a golden opportunity to make our own evaluations.

Beryllium was discovered as the oxide in beryl and in emerald in 1798 by Vanquelin. In 1828 it was isolated as the metal, by Wohler and by Bussy, independently. It is estimated to be equal to boron and cobalt in abundance and make up approximately 0.001 per cent of the earth's crust.

Beryllium is not a normal constituent of living matter and during the first eighty-eight years after its discovery, it was generally regarded as biologically inert. In 1882, Blake wrote that beryllium had the general physiologic effects of aluminum and iron. The first significant evidence in the literature concerning occupational beryllium poisoning in workers was reported in 1933 by Weber and Engelhardt. They described the occurrence of this clinical disease in a group of employees in a German plant engaged in the extraction of beryllium from beryl ore. The ill effects were ascribed to the associated anion fluoride. Additional cases of the disease were reported by Gelman in 1936, Berkovitz and Izreal in 1940, Meyer Wurm and Ruger in 1942. These European reports received little attention. Until the beginning of World War II, beryllium was generally accepted as an entirely innocuous substance in this country.

In 1939, when the large-scale development and production of the fluorescent lamp started, increasing amounts of ore were processed in this country, most of it imported from Brazil. The requirements of the fluorescent lamp and the neon sign manufactures, however; produced a sharp increase in the production and processing of beryllium oxide, the trouble started there.

The three major manufactures of fluorescent lamp in the United States started about the same time. The phosphors used to coat the glass tubes were very similar, although those used by one of the companies contained about twice as much beryllium oxide as the others. None of

these manufacturers escaped without a share of cases, but the one using the high beryllium phosphor gained the unfortunate distinction of having the first case and the greatest number of cases.

The fact that beryllium, beryllium compounds and beryllium alloys are toxic, is accepted now. Beryllium is the known causative agent that is responsible for the occupational illness characteristics to the industry. Although number four in atomic number, beryllium is number one in toxicity, of all the metals. It must really try harder than the rest.

The beryllium diseases we are concerned with here are respiratory illness and skin reactions. Primarily, respiratory illness is of concern. As you know, this illness develops from the inhalation of dusts, fumes, or mists and concentrations estimated to be no greater than 0.1 ug./m³, have resulted in chronic illness among residents living near an extraction plant. Everyone agrees beryllium is toxic but considerable controversy exists as to just how toxic. Most agree the limits are too stringent, yet they are attainable by application of the proper controls and are based on case histories and laboratory data. Adherence to these controls for exposure proposed by the U. S. Atomic Energy Commission in 1948 and still accepted today, has limited beryllium disease. These guidelines proposed and adhered to are:

- (1) The in-plant atmospheric average concentration of beryllium should not exceed 2 ug/M³, throughout an eight hour day.
- (2) Even though the daily average might be within the above limit, no person should be exposed to a concentration of 25 ug/M³ for any period of time, however short.
- (3) In the neighborhood of a plant handling beryllium compounds, the average monthly concentration at the breathing zone should not exceed 0.01 ug/M³.

Although one must consider the chemical or alloy state of the beryllium, the particles sizes, etc., the industrial hygienist must rely on the guidelines as appropriate for the total airborne beryllium and reduce as far as possible any direct contact between the workers and the dusts of beryllium containing substances.

Our interest in this problem at Ames Research Center was precipitated by an extensive program planned, using two percent beryllium in copper alloy for castings and subsequent extensive machining. At the outset of this set of tests, only the initial one was contemplated. Samples were taken to assess for the machinists, the airborne beryllium present during different machining modes. The samplers used during each machining test were placed around the test area to obtain the concentrations of airborne beryllium present in adjacent work stations and special emphasis was made to obtain breathing zone samples for the lathe operator's position. The tests were performed in as short a time as possible due to the limited casting size available. Only total air samples were obtained during the machining surveillance tests to assess the total airborne beryllium and no particle size assessments were made due to the limited sampling time.

Information regarding similar machining operations obtained from agencies surveying this type of work and machine shop personnel active in machining operations indicated no problem would exist at the 2% alloy level. We had some doubts that this was completely true, therefore, the first sample set was taken as a screening test with a minimal number of samples. This first cutting on the rough casting was performed rather haphazardly by the machinist, who was confident no problem existing and, therefore unknowingly, presented pretty near the type of sample one seldom gets, representing an actual unsurveilled condition. He was in error. The results of this test showed the normal dry machining used, created 45.2 ug/M3 of airborne beryllium in the operator's breathing zone and 2.3 ug/M3 at an adjacent machine working area. This test also showed that under the same operating conditions, a small shop vacuum system placed over the tool, effectively removed the airborne beryllium and the breathing zone sample showed only 0.2 ug/M3. The results of this first survey created a slight furor since it had been anticipated by the shop people that this machining could be performed dry with no restrictions. Therefore, another sample run was scheduled to supercede this one which to then was obviously in gross error.

In the meantime; an attempt was made to educate these people who were used to dealing in fractions of tons to just how small a ug was. Evidently this education was effective for the second run became a typical one for surveillance, wherein everything is done to minimize the situation. The cutting tool was changed for a smaller, sharper tool to produce a smoother cut and the lathe and castings were precleaned. The results obtained on the air sample taken on this second run did show the precautions had some effect but the breathing zone sample still contained 8.9 ug/M3 and the adjacent lathe breathing zone contained 4.2 ug/M3. The results of this survey created an even bigger furor since so many precautions had been taken to minimize the airborne particles.

At this point the constant education effort we were using on the shop personnel as to the actual size of the ug and the size of a cubic meter of air was convincing them the problem was indeed real. A third sample run was scheduled and an interested local agency was invited to participate in the sampling and analysis since they were advocates of the 2% beryllium in copper alloy machining being non-restrictive. This test was established to include a wet machine operation which was preferable to vacuum system machining operation to the machinists. The results of this test showed 27.6 ug/M3 of airborne beryllium in the breathing zone during the dry machining and 0.20 ug/M3 during the wet machining. All the surroundings samples were below 2 ug/M3.

No furor resulting from this survey but some analytical ambiguities existed on some of the split filter paper and additional analytical data was sought. Therefore, a fourth run was scheduled to duplicate the third run and obtain adequate samples to allow quartering the sample filters for analysis by four independent laboratories who had shown an interest in this problem. The results of the fourth sample set showed breathing zone concentrations as high as 20.8 ug/M3 for the dry machining and less than 0.5 ug/M3 for the wet machining.

Comparing the data from the four tests must be done semi-empirically since none of these tests were designed as experiments. The analyses were made to establish the airborne beryllium present during the changes in operating conditions imposed by the machine shop personnel. Many changing operating parameters were present from test to test. A few have been mentioned such as vacuum systems, water sprays, tool condition and different lathes. Other conditions changing during the series of tests considered important are: The depth of the cut, the revolutions per minute of the casting, the drafts present in the large building, and the exterior surface of the casting, which was extremely rough for the first tests and smooth for the subsequent tests.

The interesting result of the tests performed is the fact that every test made using the dry machining showed airborne concentrations in excess of the T.L.V. of 2 ug/M3.

The comparison of the data from the dry machining shows this clearly:

AIRBORNE BERYLLIUM DATA

NASA-ARC BLDG. N-220 MACHINE SHOP

COMPILED DATA FROM FOUR TESTS

<u>SAMPLER LOCATION:</u>	<u>MAX. ug/M3 Beryllium for Dry Machining</u>			
	<u>1st TEST</u>	<u>2nd TEST</u>	<u>3rd TEST</u>	<u>4th TEST</u>
Breathing zone for Machine Operator	45.2	8.85	27.6	20.8

Any future program concerning this type of beryllium alloy machining should be designed as an analytical program wherein the operating parameters can be controlled, additional samples obtained, and sufficient cutting time available to obtain particle size separated samples.

In closing, we became more aware of two well known but often overlooked ideas in creating safe working conditions.

First, don't believe in the popular opinion of people doing the work if there is any possibility of checking the belief. After all, not too long ago in some societies it was generally believed that women became pregnant from walking in the moonlight.

Second, talk to the employees involved in performing the tasks. They may not be aware of the small quantities considered toxic until you educate them. After educating people they will cooperate with the establishment. Look at our college campuses - a classic example.

N73-17059

PRELIMINARY REPORT
ON
USE OF LAHEY CLINIC AUTOMATED HISTORY
IN AN INDUSTRIAL COMPLEX

Dr. B. O. Leonardson
Assistant Medical Director
Electronics Research Center

When Dr. Lewis Haynes, Medical Director of the NASA Electronics Research Center in Cambridge, assigned me to attend this meeting, I was more than pleased. He warned me that New Orleans had numerous points of interest and suggested that I bring my wife. It has been a most revealing and delightful experience.

I was asked to give you a preliminary report of our use of the automated medical history questionnaire at ERC.

This questionnaire has been developed and used extensively at the Lahey Clinic as an aid to the appointment office in determining what department a patient should be referred to and what time for special consultations should be reserved. It has helped to maintain a balanced case load and informs the physician in advance about the patients he will see. By coordinating appointments so that the patient can visit two or more of the specialty departments in one day rather than having to return a number of times to see different doctors, it has increased our efficiency. The questionnaire is not expected to make a computer diagnosis, but screens for important symptoms or "trouble spots" to which the computer is programmed to assign scoring values which in turn point out the clinic division or section to which the patient should initially be referred.

The Lahey Clinic provides medical care for the NASA Electronics Research Center in Cambridge.

Between May 1, 1968 and April 30, 1969--5,980 visits to our health unit were recorded--of which 137 were occupational, 4,512 were non-occupational and 1,331 were revisits. During that time 550 complete physical examinations were performed--of which 348 were conducted in the Health Unit and 202 including executive physicals, laser eye examinations and consultations at the Lahey Clinic.

With 900 employees at ERC--and all entitled to a complete annual physical examination--and with only 1/2 doctor in attendance, we had a problem. Who should get priority?

Dr. Haynes and I became aware of the fact that we were repeatedly seeing familiar faces with their problems; and yet, on the elevator or down the hall were people we did not know and who did not know us. They knew there was a Health Unit, but did not relate to it.

C

With this thought in mind--with hopes of establishing even better employee-employer relationship, with hopes of interesting absorbed introverted research scientists to participate in the available health program, with hopes of keeping highly specialized expensive personnel on "the job"--the use of the Lahey Clinic automated history was introduced. Not for diagnostic purposes--only to establish priority for physical examinations.

So on May 1, 1969 a notice was sent to the permanent employees asking for volunteers to participate in this screening process and inviting them to also fill out the Minnesota Multiphasic Personality Inventory if they were so inclined. Firm assurance was made that all information obtained would be confidential and would be in the safekeeping of Lahey Clinic. Information would only be released with the employee's written consent.

Following the notice that the automated history and the MMPI were available, 272 requests for the questionnaire were filled. Of these, 195 of the automated histories were processed, 15 were returned and 62 have not been returned. One hundred seventy-nine of the personality inventories were processed, 31 returned and 62 are still out.

Of the 195 automated histories processed: 71 had never had a physical at ERC, 124 had had previous physicals (34 had had one previous physical examination, 68 had had two previous physical examinations, 22 had had three previous physical examinations).

To establish rapport with 71 employees who had never had a physical at ERC we thought was significant.

So what!!! We now had all this "print out" data. Dr. Haynes and I never realized that Dr. "So and So" down the hall was so severely depressed until the MMPI suggested that he should have psychiatric evaluation. We had never been aware the 58-year-old Mrs. "So and So" was still having intermittent vaginal bleeding.

So with all the print-outs--with names covered in order to avoid identification and to be as objective as possible, we individually rated each print-out for significant symptoms and complaints and also incorporated the Family History and when available the results of the MMPI's. Our rating closely paralleled the rating print-out of the computer.

Symptoms or history of immediate problems or life or job threatening illness were given an A priority rating--an employee who should be interviewed and examined at the earliest possible date.

Less suggestive "print-outs" with questionable life or job threatening illnesses were given a B rating--and those with no complaints and normal histories were placed in the C group.

Of the 195 processed automated histories 53 were given A priority, 59 B priority and 83 were placed in the C group. Since June 30 complete physical examinations and interviews of the A group have been completed plus 35 employees in the other groups.

One of the purposes of this research project using the automated history is to determine its reliability. The questionnaire must be changed and, in fact, is undergoing its eighth revision at present.--The problems of hearing a patient talk, seeing his facial expression, noting the odor of his breath and his emotional attitude will never be completely taken over by the computers. Computers were man-made and are programmed by man and sometimes may merely automate a defective status quo.

Up to this point the main difficulty with our automated history is one of semantics which I am sure our computer and programming experts can correct.

My personal feeling is that the automated history has a place in screening an industrial complex which has such health fringe benefits as offered to NASA employees.

NASA scientists are unique--questioning--skeptical--but as is becoming evident from our brief study, seemingly more willing to relate their problems to a computer than to a man or physician. However, it has been increasingly apparent that the physician's "mind computer" with its associated understanding, compassion and sympathy plus clinical judgement and experience will never be replaced by any depersonalized man-made machine computer--however, the computer has afforded a new means of establishing rapport.

I trust that when our study is completed in May 1970, objective evidence of its usefulness may be presented.

173-17060

REVIEW OF A SERIES OF PROCTOSIGMOIDOSCOPIES
DONE AT WALLOPS STATION, VIRGINIA

Dr. Edward White
Medical Officer, Wallops Station, NASA

(a) The Subject:

The subject of this study is a series of 530 proctosigmoidoscopy examinations done at the Health Unit at the NASA installation at Wallops Station, Virginia, between the years 1964 and 1969. The only positive findings I am reporting is the number and incidence of polyps found on these examinations during this period of time. I am not attempting to report on any other pathology such as hemorrhoids or fissures, etc.

(b) The Value of Routine Proctosigmoidoscopy:

In a paper in the Journal of the American Academy of General Practice in the June 1960 issue, Dr. Gordon McHardy, Louisiana State University School of Medicine, New Orleans, and his associates, pointed out the value of routine proctosigmoidoscopies. He stated that routine proctosigmoidoscopy in asymptomatic patients may result in the early detection of cancer of the rectum and sigmoid with curative operation and therefore greater survival rate in addition. Early detection of a malignant polyp without invasion beyond the stalk may permit a less extensive curative operation than a complete proctectomy and colostomy required when the lesion is discovered in more advanced stages. He further quotes some statistics from the American Cancer Society showing the estimated number of deaths from cancer of the colon and rectum in 1965 was 43,000. This was second only to death from cancer of the lung which was 50,000. New cases of cancer of the colon and rectum in 1965 number approximately 73,000 while of the lung only 55,000, so we can see from this high instance of cancer of the colon and rectum every effort should be made toward early diagnosis. There certainly is some controversy among surgeons about the value of routine proctosigmoidoscopy and also the relationship of polyps to carcinoma. I do not intend to go into this in this report.

(c) The Material:

Gentlemen, I wish to stress the fact that these examinations were done on routine physical examinations on completely asymptomatic patients as far as symptoms of the bowel are concerned. The proctosigmoidoscopy was offered to everybody receiving a physical exam at Wallops, and approximately 50% accepted them. As I say, we did not attempt to just offer the examination to symptomatic patients. In fact, in several cases where the patients would complain of diarrhea or something like that, they were referred to their own physician for an examination. These proctos were done on pre-employment physicals, health

maintenance examinations, and job physicals. The only cases where we did not offer exams were to a few young co-op students in the age group 19, 20, and 21 years. The personnel were in a great majority from NASA installations but we had a few from the United States Weather Bureau at Wallops and also from the Tiros Operational Satellite Station. We do not examine at Wallops any of the contract personnel so they were not included in this study or they did not get an examination.

(d) The Equipment:

The proctosigmoidoscope was a Welsh-Allen scope. The table used was a Ritter hydraulic table. I will show a picture of this in a few minutes.

(e) The Preparation of the Patient:

When we first started doing these examinations, these proctosigmoidoscopies, we had a much more elaborate preparation of the patient than we do now. At that time, we regulated the patients diet the night before. We did not permit a big meal such as cabbage or a lot of meat or spaghetti or anything like that. And, also, we gave him a laxative on the evening prior to the examination such as milk of magnesia or mineral oil. The next day we tried to get him to take an enema before he left home and then we would repeat the enema just before the examination. However, we found that this elaborate preparation discouraged a lot of people from having the examination, so we finally decided to just give an enema before the examination. So now when the patient presents for the examination, we give him a fleets enema which he gives to himself and after initially using the ingredients in the fleets enema we then tell him to put some tepid water from the tap in the bathroom and repeat the enema three or four times or until it comes back clear and with this we have had good results and been able to get a good visualization of the rectum and part of the sigmoid. This is not as sterile a bowel or as clean a bowel as a surgeon would like to have, but we were doing this just as a screening procedure. I realize that when pathology is found and the patient goes to the surgeon, or patient has symptoms, the surgeon is going to fulgurate or biopsy or something like this, then he needs the bowel to be as clean as possible, but for a routine examination I think a fleets just prior to the examination is all that is needed or in our experience is all that is needed.

(f) Some Excuses for not Having the Procto Done:

Now as I said previously, approximately 50% of the people at Wallops took the examination and approximately 50% turned it down. Now the reasons for turning down the examination were several. One reason was that the examination and the prep interfered with the patients

bowel movements and his normal routine. However, when we stopped the elaborate preparation that I mentioned a minute ago, this excuse disappeared and several people who did refuse it now take the examination. Other excuses were hemorrhoids, not having any trouble right now, not having any trouble with their bowel movements so why take the examination, and this we are slowly trying through the process of education to make the people realize that the examination is best for them before symptoms occur. We are having some luck in doing this and the percentage is starting to pick up some.

(g) Types of Polyps:

All the polyps were found to be adenomas.

(h) During the Examination:

As I said, after the patient takes the enema, he gets fairly well cleaned out. He is put on our table and the table inverted and I keep trying to reassure and tell the patient that any time he wants me to stop I will be glad to stop. I think this gives the patient a better feeling, realizing that if it gets painful, I will stop immediately. With the patient in an inverted position, I first do a rectal examination covering all points of the rectum, going around the rectum clockwise, and this I think helps relax the anal sphincter a little bit and makes it easy to introduce the scope. The subjects complain more of my finger than the scope.

(i) Discussion:

There is certainly, at the present time, some discussion among surgeons about whether polyps or little adenomas when they are found, if they should be removed or followed, well, the majority of surgeons in our area feel that these polyps should be removed, so any polyps found were referred to the surgeon and they were fulgurated or whatever was needed. Usually went through LMD, but few people do not have LMD, so we refer directly. Whether carcinoma arises from polyps is still controversial. At the present, some people believe they do and other people believe there is no relation between the little polyp on the adenoma, and carcinoma. However, as Dr. R.D. Liehty and his group at the Department of Surgery stated in a paper on disease of the colon and rectum, May 1968, that if polyps are found, even though they are not malignant, they may signal the need for barium enema and the malignancy might be found further up. They reviewed 2,261 cases of cancer of the colon and rectum over a twenty-year period and found that over 50%, or 1,120 lesions, were situated less than 25 centimeters from the anal verge and were in reach of the proctosigmoidoscope.

Sensitivity to Emotional Ill Health

N73-17061

in

Employed Groups*

by

Jean Spencer Felton, M.D.†

"Subtle, pervasive, and disruptive are useful adjectives to describe the characteristics of a majority of emotional problem cases in industry; subtle because the behavior of the individual is often not blatantly abnormal; pervasive because it can involve a unit or section for a considerable period of time before being properly identified; and disruptive because it so often distorts interpersonal relationships, and such relationships are at the core of effective functioning of a unit."

Robert B. O'Connor, M.D.¹

Preceptive in the operation of a social institution is effective functioning. The need for the maximum in human performance is all the more mandatory when the activity involves the use of public moneys, and the managers of those funds are remote designates of the tax-paying electorate. Particular emphasis on skill and efficiency is required when the supporting public has only a dramatic end result to judge by, and is unaware, usually, of the main minor successes which have given possibility to the major accomplishment.

There is further significance to effectiveness when the work processes are creativity and abstract thought rather than the unimaginative produc-

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tion of millions of marketable units utilizable by the individual homemaker. Art, research, literature, and dramatic performance, although subject to knowing professional, critical review, frequently are believed to be easily reached products that "anybody could do." Hence, the sharper the barbs which are levelled at the initiator, the planner, the designer, the thinker, or the theorist, by the person who sees only the slow process of creativity, yet expects the hustle, noise, and momentum of, say, a can factory. Responding both to a demanding public, or its selected officials, and an exacting management, the space worker has high expectations placed upon him. Meeting these expectations may be accomplished only through tremendous drains on his emotional economy.

Contemporary Mental Health Programming

In a discussion of emotional health with responsible and thoughtful occupational and environmental health directors from a large governmental agency, it seems only logical that the experience and views of this disciplinary body serve as the platform for a conceptual interchange. About two months ago a letter containing 10 questions (see appendix A) was sent to 50 persons listed as "key medical and environmental health personnel" in NASA headquarters and its primary installations. Replies were received, either detailed or cursory, from 11 physicians, six environmental health directors, and four lay medical managers, a total of 21 responses.* In five instances the environmental health personnel deferred to medical opinion at their sites, and 1 disclaimed all knowledge of this area of inquiry.

Of those not replying, there were nine physicians and 18 environmentalists, a total of 27, or 54 per cent of the group originally solicited.

* This number included opinions from two persons to whom the questionnaires were not sent, but who were in positions permitting opinions of worth.

Two of the reactions to the questionnaire were received in the form of telephone communications.

The information returned coursed from great awareness of emotionally generated problems at operational sites to complete disclaiming of the existence of such difficulties among workers. The environmentalists -- including industrial hygienists, health physicists, safety directors, and environmental health engineers -- ranged similarly from great sensitivity to work behavior to, presumably, a lack of knowledge or disinterest. Many of the replies were highly insightful and provided substantiation for a presentation in this particular occupational health area.

Specifics From the Field

Although the speculation can be broad regarding the nature of certain responses from certain individuals at certain installations, only some of the highlights will be offered.

Formal Program of Identification

No formal effort exists to identify behavioral problems among local personnel. The primary source of recognition lies, at one installation, in the product of a detailed automated medical history coupled with the Minnesota Multiphasic Personality Inventory (MMPI). The respondent reported that in many cases the responses to the two documents, when reviewed with the physical examinee, led him to discuss family and work problems which might not have been flushed out in the usual seeking of the medical history. At other sites, leads are obtained during pre-placement or periodic medical examinations, or during visits of employees to the health service. Several of those replying stated that supervisors and security officials will serve as informal sources of referral of workers in need. At one research center, as part of a training program for supervisors, copies of the Civil Service Commission publication, Recognizing and Super-

vising Troubled Employees, are distributed. No evaluation of this procedure was mentioned.

Use of Mental Health Specialists

Nearly all medical services refer troubled employees to specialists extramural to the base. Primarily, psychiatrists are used, and when the health program is based in a large adjacent private clinic facility, staff members in psychiatry or psychology see workers on referral. No mental health specialists visit the local health services.

Sensitivity to Problems

Most of the physicians responding felt that their medical staffs were sensitive to personality change or problems, and several accredited to their nurses keenness in this kind of awareness. There was a feeling that nothing was done unless a behavioral question at issue became truly acute and then referral would be effected. Lacking was a sense of early intervention when help could be offered prior to irreversibility of the personality aberration. Few of the medical or paramedical personnel had had special training in occupational mental health.

Predominance of Problems in Specific Group

Because of experience many years ago with workers in the atomic energy industry, I have been curious as to the personal needs, or deficits, as manifested by behavioral differentials among various groups of craftsmen, scientists, engineers, managers, or other occupational incumbents. There has been concern over the move into administrative posts of engineering and computer science personnel because of their concern with "things" and problem-solving rather than a concern with, or an appreciation for, the delicacies and intricacies of interpersonal relations. The respondents

were divided on this point, probably in proportion to their interest. One felt that rotating shift workers had a great number of personal difficulties, usually at home, or with alcoholism. Another specified personnel at lower grades for they lacked understanding in the use of community resources. At one installation, technical and mechanical workers, professional engineers, and managerial personnel were placed in this order of frequency in demonstrating personal problems.

One respondent verbalized his selection as follows: "In general, the research scientists pose the greatest potential problem. Some live in a private world of their research and are completely oblivious of what goes on around them." From another observer came this paralleling statement: "At _____ there is a definite increase in emotional problems among the scientists working on research projects. They are...trying to plan environmental studies and programs for flights anticipated in the late 1980's. They are working with many imponderables and unknowns and feel very insecure when their work is not showing the productivity that they feel their supervisor is demanding. This coupled with the fact that NASA is new and there has been constant reorganization of the various scientific departments here...would result in insecurity."

At one large facility, administrators were considered as the group in greatest need of personal problem resolution. Several of the respondents felt there was equity among all worker segments, and at one installation a study is being conducted to measure this point of group difference.

One writer made the interesting statement that, "Our employees are typically mature individuals having an average age of 47.4 and an average of 19½ years of Federal Service. In this small organization working with mature professional individuals, we have not felt the need to establish

any formal mental health program." It is of interest to read that being a quadragenarian implies "typical" maturity or that two decades of Federal employment will bestow a comparable freedom from emotional disruptions.

Examples of Impaired Functioning

The cases cited were of extreme interest and underscore the fact that whenever people are at work and endeavor to meet the daily environmental challenges, imbalances between personal strengths and external stresses will result. The illustrations are paraphrased.

Example No. 1

An electronics technician had recurrent "manic episodes" which required several hospitalizations. Rehabilitative trials through the team effort of the private psychiatrist, the health service physician, and the supervisor had been partially successful only. Although there had been long remissions related to lithium therapy, the employee has required tremendous expenditure of time and energy by Management and health service personnel.

Example No. 2

A 55-year-old, working in procurement, was extremely conscientious, competent, and efficient. He was of Irish lineage, and a younger man of Italian ancestry who worked for him was promoted over him as his immediate chief, possibly because the younger worker was much more aggressive. The 55-year-old became severely depressed, developed insomnia, was emotionally unstable and totally frustrated in being unable to find a position to which he could transfer, in his field and at the same GS level in the

large metropolitan area where he worked. The condition was not improved by a two-week vacation, and currently he is receiving psychiatric counsel. Up to the point of the change, his work has been outstanding, and he had recently received a merit promotion.

Example No. 3

A senior and highly qualified employee, divorced and living alone, became an alcoholic because of his continuing difficulty in meeting the legitimate demands of his supervisor. He could not measure up to the standards required and would avoid meeting the supervisor or performing the work by taking sick- or annual-leave and by over-indulging in alcohol consumption.

Example No. 4

A 46-year-old employee developed symptoms of extreme anxiety, had repeated periods of absence, and demonstrated fractious behavior, even toward the medical personnel. On investigation it was learned that the man's complaints about his supervisor were not unjustified. It could be documented that the supervisor had indeed put abnormal pressure on this worker to the point that he was using every mechanism available to him to avoid being at work and to avoid staying at his work station while at the facility. A transfer to another area and to another supervisor completely resolved this immediate problem.

Example No. 5

According to the employee who had been having difficulty with fellow workers, they had "picked on" him. He stated that the other men were trying to have their supervisor replaced

and that he had refused to take part in it. One night, armed with a loaded gun, he went to the homes of two of his fellow workers. He found one at home, and told him he would have shot them both if they had both been there. The one who was at home finally talked the patient into giving up the gun. He removed the bullets and the next day at work returned the gun to the patient. Three days later, the patient called another co-worker who was at home ill, and told him he (the patient) would have to get rid of six more people "before things would go right out there." A warrant was obtained, and the patient was picked up as he was leaving work, was detained in a psychiatric ward for two days, and was released under the care of his own psychiatrist. Subsequently he underwent disability retirement.

Example No. 6

In a particularly difficult situation, a research engineer believed that his investigative work had been "stolen" by some of his peers and supervisors. Counseling and medical care failed to rid the employee of this deeply ingrained belief. In the absence of a frankly diagnosed psychosis it was necessary finally to take disciplinary action. The entire case involved many hours of time of personnel including that of the Assistant Director.

Example No. 7

Most outstanding among the specific cases cited was one which involved a group of 150 craft workers highly skilled in meeting the exacting requirements of the engineers. Under a change in unit heads, the men became thoroughly demoralized.

There developed universal unhappiness, for what had been an elite group was now not unlike the workers of a production shop, where no longer was there the sense of one-of-a-kind production.

A planning group had been interposed between the craftsmen and the engineers so that the value and worth of the former close association now were gone. The employees had difficulty in articulating clearly their complaints, but when pressed to do so, stated that they were "treated like machines," having developed a sense of worthlessness, both personally and occupationally. They were trapped by long periods of service, not willing to forego long-structured pension privileges. Most of them could tell to a day, the time remaining until retirement.

Reorganization had been effected through the issuance of memoranda, without a personal orientation or clarification as to the changes, and without the opportunity for the men to respond. An interesting side light was that the workers had, in many instances, brought their own tools to the shop; now, they had taken these home, and were using those issued in the facility. Many of the men sought tranquilizers from the medical unit in order to continue their jobs, and one employee has been seeing a psychologist weekly, solely to release the anger generated by the work situation.

When the problem was presented to management, both the Director and Personnel Director felt restrained by Civil Service Regulations in being able to cope with it -- and the big blow goes on.

Relationship of Behavior to Performance in Observance of Precautions

Significant responses came from some who were working in environmental health. In one center, instances have been noted where, for no apparent reason, workers have refused to use personal protective devices. Some of these actions were believed traceable to abnormalities in personality of the employees involved. One instance had been recorded where an individual had purposely exposed himself to a specific material, developing a dermatitis in hopes of being transferred to another job. In some jobs carrying the so-called "he-man" image, such as steel-workers, workers have been observed refusing to wear safety devices for they felt that their use carried with it a "sissy" connotation. Another abnormal action consisted of the intentional exposure of film badge dosimeters by radiation workers to high levels of ionizing radiation.

The antithesis of this was encountered in a young scientist from abroad who became totally inefficient because of his fear of ionizing radiation. In spite of measurements by health-physicists and reassurance that there was no hazard, the man believed, as a scientist, that the established criteria were not sufficiently protective, and that his life was still in danger. Eventually he had to be discharged.

Occupational Mental Health Programs

In the main, no programs in this area have been launched. At one installation "a modest program" has been followed, consisting of detection through employee-patient visits and referrals from supervisors; rehabilitation on return to work through the team approach; follow-up on specific problems; consultation for employees with emergency status; training of supervisors in mental health; and investigation into work activities suspected of causing or triggering abnormal behavior patterns.

The only other effort reported came from a medical care source where there was a joint concern in alcoholism exercised with a local Alcoholics Anonymous group made up of several of the scientists who offered aid in caring for the problem when it arose.

Assistance Valued in Program Creation

Six of the respondents stated specifically that they would welcome assistance from mental health professionals in establishing a program, but that such an effort should be built into the on-going medical activity. There was one "maybe," and one person said "no." There was a comment in this connection redolent of days long past: "People are afraid of the words 'Mental Health.' They still associate 'Mental Health' with insanity." Worded specifically, one respondent stated that, "Any assistance leading to prevention of interpersonal conflict or emotional problems which can be effectively utilized would be welcome." At one installation, the medical director felt "the main effort now should be directed toward selling Management on the need for a comprehensive mental health program."

Sensitivity Training

Two of the persons queried replied that sessions of this kind had been conducted, and one mentioned a three-hour seminar on mental health which was included in supervisor training, as was a special series of "executive training sessions," of one week's duration, on a live-in basis. Such group efforts "were not encouraged" at one site, and at another where the group format had been used, "the response...was as varied as the personalities of those employees who took part in them." One comment was comparable to some of the remarks regarding civil rights -- "Sometime

in the future we may, but for now, we will have to wait and see."

Comparative Prevalence of Problems

In the main the consensus was that NASA workers, in comparison with groups in other industries, did not present any more problems than others. Some felt that this related to the careful selection of government employees.

Indications of Need

Nearly all evidence proffered by stressed employees can be subsumed under the designation of symptomatic behavior. The actions manifested by workers bespeak underlying turmoil even though the casual view of these persons may be unrevealing of any change in homeostasis.

Partial Withdrawal from Work

Even though a distaste for work has become a commonly bantered folk expression among Americans, work is a personally meaningful activity. Yet, when an individual is placed in an assignment anathema to his wishes, antithetical to his particular sensitivities, or polar to his particular value system, he is going to avoid, consciously or unconsciously, continuing contact with the stressor. He will escape for whatever brief time he can.

Chronic or repeated tardiness relates personal difficulties at home, or a disinclination to perform for a full day of work. Excessive duration of coffee breaks or similar work stoppages exercised over the allowed number, or constantly lengthened lunch hours permit the employee to shrink his actual work contact period. By absenting himself from the job, he elongates the separation from the unpleasant work scene. Inquiry regarding cause of the absence will evoke, usually, a wide variety of rather tired explanations relating to alleged personal illness, transportation breakdowns, or family crises in need of resolution. A supervisor need not be astonished by some of the bizarre rationalizations offered by employees highly experienced in this activity, and skilled in verbalizing with the straightest of faces.

Equally divisive of the employee from the work scene is a self-imposed task underload. This is seen in the individual who cannot produce the totality of what is expected within the normal time span. Again, there are always articulated excuses for not meeting deadlines or full production quotas or even top quality if it means an unusual effort.

Each of these behavior patterns depicts a disaffected person who will not meet work expectations for reasons to be determined by professional workers adept at teasing out the true causation from among the many superficially expressed and unsubstantial etiologies.

Total Flight

The syndrome of partial withdrawal can be extended to its fullest in the form of total flight from the site of stress. The worker manifests this by requesting frequent transfers from one job to another, or from one department to another. The stay in each may be of short duration, ending frequently in poor performance, supervisory dissatisfaction, or fractured interpersonal relations of the employee with his peers.

Turnover tells a tale of tension, either on the part of a single worker, or of a group. The job-hopper, the individual who has worked for many companies in a short period of time, is to be suspected of an emotional difficulty, for most persons in the labor force can demonstrate infrequent job changes. The solid, concerned employee learns new ground rules, establishes an appropriate set of work standards and adjusts to the needs of the position just obtained. Exploration of the basis for unduly frequent moves will elicit plausible explanations, but on finite dissection, there will be always uncovered certain situations or persons who will be blamed or viewed as the reasons for the individual's removing himself from the particular group or situation.

In studying the persons undergoing personal flight, it is always helpful to know if many have left a single unit, for often this is the only indication of stressful supervision. Like several of the examples cited previously, a foreman or leader common to a group of leavers might be identified as the problem universal to the resignees.

Partial Self-Destruction

For whatever unconscious reason might exist, a worker may attempt to destroy himself in part, because of what he perceives to be an intolerable situation. At one end of the spectrum is seen the person who undergoes work-overloading, and takes on many more assignments than he can either complete in a given time span or carry out with quality performance. Frequently this is done because of a long enduring habit of establishing standards for personal accomplishment which exceed reality.

A variant of the theme of self-destruction encountered in a more overt manner is seen with the employee given to "telling him off," when the "him" usually is his supervisor. This effort at "pointing out the truth," or "setting him straight," or not letting "him do this to me," usually leads to disciplinary action taken because of insubordination. The self-inflicted punishment may take the form of a reprimand, suspension, or discharge, any one of which partially destroys the employee when either his future with the company or his career is considered.

More dramatic forms of this behavior pattern are seen in "accidental" injury, particularly in employees who constantly re-injure themselves in a variety of work settings and with the involvement of diverse tools or equipment or vehicles.

Chronic alcoholism and drug abuse have serious consequences in employment, and are not only physiologically but vocationally destructive.

Total Self-Destruction

Lastly, there have been many depressed workers who have attempted suicide in more conscious fashion than through a job-related injury. Many times these attempts take place at the worksite or shortly after leaving. In a great number of instances, there is no explanation for the action and, on review, no tell-tale clues were recalled or found.

A most memorable suicide taking place in the health service of a government agency was the one reported, in essence, as follows:

A white collar worker came to the dispensary stating that he was feeling ill and wished to lie down for a while. The Occupational Health Nurse gave him some medication and led him to a bed in the rest ward facility. Within a few minutes after she returned to her desk, she heard a gunshot from the rest area and on returning quickly found that the man had committed suicide.

Although more prolonged in the process of self-elimination, the two polar actions of excessive weight gain and excessive weight loss may be included. Many applicants for employment who demonstrate obesity may undertake crash dieting in order to meet a physical standard. Shortly after beginning the new position, the weight will return to its initial level.

The long-known entity of anorexia nervosa is seen infrequently but the destructive process is inherent in a self-enforced drop in weight either through the cessation of eating, or the ingestion of extremely low-calorie, high-bulk foods. At the moment of writing, an employee with this condition, in one of our departments, has gained a few pounds during the initial months of a work probation period in order to meet the weight criterion. It will be interesting to see if, when tenure of employment is obtained, the weight will remain at its new height or will drop to its morbid average.

Signs of Stress

Workers plagued by personal concerns almost flaunt the tell-tale signs of stress, for, in a sense, they are seeking help which they are unable to ask for in the more usual format of requesting assistance. The sensitive physician or paramedical specialist, with perceptive acumen, will identify the behavior patterns indicative of turmoil within.

An increase in the amount of dispensary visitation is a clue. The ostensible reasons might be major or minor illnesses or injuries; simple requests for information or merely conversation; the need for confirmation of a private physician's diagnosis or treatment plan; or the need for "just a couple of aspirins." The characteristic is not the nature of the visit to the medical department, but the frequency. There are the innumerable contacts with members of the professional team which ordinarily end in the staff member's providing what seems to be indicated. But a permanent meeting of the recidivist's needs will take place only when a wise physician or nurse or technician will suggest that the deep reason for the many visits be explored and identified. Sensitivity to the needs may be shown by a clerk or a receptionist who has a feel for what is really indicated by the many dispensary contacts.

Certain psychophysiologic responses are commonly seen as reactions to stress: tension headaches, gastric, or more frequently, duodenal ulceration, neurodermatitis, myocardial infarction, or cerebrovascular accidents. To be sure, the matter of organ selection is never clear. Why does one person -- or one family -- develop headaches as a reaction to pressure, while another consistently has his skin speak for the external impingement on his emotional economy. Even minor clinical conditions, aphthous stomatitis or herpes simplex, can have their origins

traced to a slowly accelerating stress. It need not be said that the patient-employee presenting any of these disorders must be studied multidisciplinary, and not have the controlling clinical judgment exercised solely by a rigid somaticist.

Domestic Problems

Although many laymen believe with the most solid of convictions that work causes difficulties in emotional balance, persons in constant touch with employees see home problems which can be faulted as causative of ineffective job performance.* Family differences between parents and children, particularly those seen today when an irrational reaction to hair's length or skirt's brevity can lead to long-enduring alienation, are brought to the job and becloud or limit the peak expression of occupational skill. Working parents cannot shed the weight of their worries when they begin the workday, and the product, the service or the consultation turned out is lacklustre in quality.

The working mother will, as she always has, lead two lives, and the demands of family integration will lead to tardiness, absence, excessive telephoning, or shortened workdays because of baby sitter, nursery school, or transportation constraints. Even though all elements of the planned existence may go according to the most exacting of timetables, she still has family tasks on arriving home. It is a busy, a full, an emotionally split day she spends as an employee.

If the working mother happens to be a professional person, and if her husband has a comparable career, there may be rivalries between the two which could prove divisive rather than cohesive. (While speaking of sex differences in the working population, another strange item in status should be mentioned. A woman executive's secretary is of lower

*To be sure, work situations can, and do, lead to emotional disruptions, but usually when predisposing factors in the worker's life are re-kindled by a stress which cannot be coped with by the person's usual life style of meeting pressure.

status than the one who works for a man, according to unofficial hierarchical values of secretaries, and this may lead to problems with the secretary or with the executive.)

As a final example of difficulties tangentially related to the domestic scene which encroach upon work, there is the problem of transportation to and from work. Temporary blocks to traffic on freeways and expressways, vehicle breakdowns, and the constraints of carpools may be reflected at both ends of the daily trip and not only relight short fuses but replace effectiveness by impaired performance.

Racial Difficulties

Lastly, there are the disturbing elements in human relations brought about through ethnic differences. Whereas at an earlier date a black person would not be hired because of his color, irrespective of his capability, today there is the reverse of the coin in the employment market. Many blacks are being sought for good positions, but the prospective worker wants to be sure that he is being employed for his capacities and not merely because of his color. Wisely, these persons do not want to be the token employee, or as a black psychiatrist friend of mine put it, "I don't want to be _____'s nigger boy."

Discrimination and prejudice are terms or feelings interpreted and misinterpreted as different viewers describe the scene. An incapable black accuses the employer of bigotry if another person is hired (black or white) who has greater efficiency in performance to offer an organization. If such an employee fails to work out well, it is because -- as perceived by the complainer -- the company, the employer, or the supervisor is prejudiced. The understanding that one must produce, irrespective of hue, is yet to pervade the thinking of vast numbers of

workers. Also to be rectified in the thinking of personnel is that the status of a position itself does not necessarily permit mediocrity or sloth, but is more demanding of quality work than were the status lower. It is hoped that the Peter principle will not enter into industry's efforts to place members of minority groups.

As workers are being recruited from poverty areas, one sees great pressures exerted on the new incumbents. There are, in essence, two cultural shocks experienced by the worker from the underprivileged area. First, he emerges from the ghetto to enter the community at large, which is an action in itself productive of apprehension. The second shock follows the move into the industrial society with all of its regulations, mores, behavior demands, jargon, and individual missions. To adjust to both sudden shifts is a formidable process, and some are unable to remain within the physical and emotional confines of a job's "territory." It is almost impossible for most supervisors to realize the dimensions of these changes and their patience is tried as each endeavors to adjust to the other's demands or lacks. One day, the requirements of formalized or structured work will be realized, and the tensions between supervisor and supervised will ease.

In our own department, we placed an 18-year-old from a poverty area. He was a 10th-grade dropout and on being assigned to the Radiology Section to assist in film processing and filing, appeared in full-length laboratory coat. Having donned the garment, he believed himself to be a professional person. The absence of reality thinking was further underscored when he was asked about his vocational aspirations. He stated that he wished to be an electrical engineer, his response completely unencumbered by any knowledge of the educational preparation required. His tenure was short for, in spite of encouraging guidance and lengthy tolerance of behavioral deficits, neither his presence nor his promptness could ever be assumed.

What Can Be Done?

Train Staff in Problem Recognition

Through training, the staff can be sensitized by a mental health specialist, brought in as a consultant, to the personal needs displayed by employees. He can interview individual employees or job applicants, or he can review case histories presented at staff conferences, pointing out the behavior manifested and its most likely etiology.

Group sessions can be held so that staff members' attitudes can be queried and explored. From these can come understanding of one's own behavior, and, secondarily, insight into the behavior patterns of others. Encounter groups of this type may be traumatizing to both fragile, poorly woven personalities and rigid and brittle individuals, and should be conducted only with the leadership of one trained in this learning format.

Most needed is the nurturing in the staff member of the curiosity to ask himself of a problem-beset employee, "Why did he do this?" or "Why did he say that?" or "Why does he relate badly to older men?" or "Why are his technical skills so superb and his social skills so immature?" There must be this intellectual questioning of behavior styles as part of learning. Further, with the understanding that will come from any of these self-growth mechanisms, there will be a replacement of the more primitive responses one might feel on interacting with a difficult worker -- anger, punitive action, dismissal, or hasty, dismissing referral.

One can be guided by performance evaluations prepared by the troubled employee's supervisor. These descriptions can bring into focus behavior characteristics which the patient has repressed, or does not wish to mention. The astute supervisor, while not always an interpreter, is usually an excellent observer, and his comments can serve as clues and guidelines in working with an employee. An example of one action

involved our own department. A supply clerk elsewhere altered a requisition so that our request for 5,000 tongue depressors, a four-months' supply, materialized into the delivery of 50,000 such items. When asked the reason for the change, the response was, "I wanted to teach X [our order clerk] a lesson." There was no basis or need for the "lesson."

There is a genuine roadblock in identifying persons at emotional risk, and this is attested to, with considerable feeling, by one of your own medical directors, when he wrote,

"Some of the most formidable problems we face here [relate to] the directives of the Civil Service Commission in Washington [which] have made it literally impossible to legally delve into emotional or psychological profiles of any civil servant. This has proven to be a real handicap to all of us in many ways. In all candor, we find that the personnel divisions are... operating at their wits' ends in almost every instance of a problem involving a NASA employee who is having any behavioral problem of any sort. They are literally frightened to the point of inactivity in most instances for fear of being found vulnerable to attack by individuals oftentimes represented by their union who have been encouraged by the Civil Service directives resulting from our well-meaning members of Congress in this misguided efforts to properly protect an individual. They have, in fact, almost completely obviated any effort to [ward] a pragmatic approach which certainly has been a time-honored, well-established and effective program in many industries."

The essence of the complaint is that physicians working in federal installations may not use a printed medical history form which contains questions in sensitive areas. They are permitted, however, to ask these questions in conjunction with a physical examination and record significant answers. The form will be maintained in a separate, locked file. ² Medical questionnaires are invaluable in eliciting pertinent behavioral data, and, in their development, it has been demonstrated that they bring to light more clues for diagnostic search than the history taken orally by the physician. One day, their use may return when medical policy is determined by persons in medicine and not by those in administrative or legislative areas.

Train Staff in Reassurance

Members of a medical department can be trained in listening. Implicit in listening are total attention; observation of all gestures, facial expressions, and positional or composure changes; hearing of alterations in manner of speaking; and the elimination of all disruptive interventions such as telephone calls, or the entry of other staff members. Listening means hearing not only the words spoken but the tone with which they are uttered, and correlating the words with hesitation in speech, with eversion of glance, with crying, or with anger.

Listening means, in addition, maintaining silence when the patient is silent, and avoiding interruption of an unfinished sentence either with words of tangential significance or by completion of the sentence.

Reassurance carries with it the provision of emotional support, and this can be effected in different ways as determined by the intelligence level of the employee, the nature of the worry, or the

duration of the problem. One usually speaks of the worker's being "upset," rather than "disturbed;" he has been subject to strain, or stress, rather than his having a "psychological problem." Stress, in all forms, is in common parlance today, and the word enters a number of disciplines. It may be considered fashionable to be stressed, but deprecating to be churned psychologically.

In reassuring a distraught person, one emphasizes the lack of uniqueness of the problem, and the knowledge that such a situation has been faced by innumerable others in the past. One points out that the problem will, in no sense, make medical history, reassuring the individual by emphasizing the commonality of the difficulty. So many troubled employees believe themselves the only ones who have become embroiled in their particular difficulties. Confirmation that hundreds have had similar difficulties is reassuring for it no longer makes them alone in society or different from other humans. Reassurance does not imply that the problem is viewed lightly or as insignificant by the listener; rather, when provided warmly, establishes contact with the troubled person so that he will accept the options in care.

Basic to reassurance is the clarification of need. The professional explains the need for counselling or therapy; that medicines are not indicated; that the physical symptoms are speaking for unsettled emotional requirements; and that care does not necessarily mean unending analysis or institutionalization. To be given emphasis, though, is the sense of immediacy in meeting the need for professional attention, and that procrastination will intensify, rather than resolve, the problem. Reassurance is always accompanied by the explanation that there are methods of resolution and that there are trained people skilled in working in these areas.

Train Staff in Referral

Referrals made for such employees are not to be accomplished in a cursory fashion. An appropriate counsellor or therapist should be selected, and, if agreed upon by the patient, should be informed by telephone of the service requested, of the peculiar needs, and of the pertinent historical, behavioral details. This should be followed by a letter confirming the discussion. The person making the referral should request specific assistance if an administrative decision rests on the consultant's opinion. Should this person return to his present job assignment? Should he continue to work while initiating care? Should arrangements be made for long-term care (sick leave, authorized absence)? Should his job be enlarged, diminished, or remain the same? Is he in need of a different supervisor? What is the work-life prognosis? Only by placing these specific questions can one be given leads in guiding management when the employee's problem distinctly affects his work capacity or performance.

Referrals are not to be handled lightly on either side. The patient must be informed of the nature of the consultant -- that he is a psychiatrist, a psychologist, a counsellor, or a behavior-oriented internist. Further, the patient should reach an understanding at the time of the first visit of the professional fees and his financial obligations. If these cannot be met, then further assistance is required in seeking other referral sources where the costs are less or there are no charges.

Staffing

The addition of a mental health specialist to the medical department staff will bring unequalled in-service educational opportunities.

As a base for teaching, there are certain employees whom he might see on referral from the physicians, nurses, and environmentalists. Case reviews, as indicated previously, are invaluable instructional aids, and create ports of entry for the psychologist or psychiatrist or psychiatric social worker to consult with supervisors and members of management. The addition of such a person was suggested in a study conducted at NASA headquarters several months ago, but nothing has materialized from the fine review carried on of personal needs at that site.

Most rewarding is the clarification of worker behavior patterns, so that the employee presenting any of the syndromes indicated before can be viewed in the new light of understanding and helped affirmatively and with confidence.

The Medical Director has an important role in a program of mental health. He can orient members of management to the entire subject of behavior, supervisor identification of problems, referral, and probably, most importantly, to the essential qualities of patience and tolerance, new to many mission-consumed top administrators. Further, he can orient new employees to the diagnostic and therapeutic methods utilized in a behavior-conscious medical facility. This will prepare future patients for the kinds of queries and type of individual concern to be found when reporting to the health service at time of need. To be averted is the frequent rejoinder encountered which, in paraphrase, goes, "All I wanted was some aspirin and they psychoanalyzed me."

The Role of the Environmentalist

In the responses received from the environmental health personnel, there were few comments regarding worker behavior. In the motion picture film developed and shown here, descriptive of industrial hygiene activities, the environment was considered strictly as a physical-chemical-biologic complex, with no behavioral aspects or content.

Physicians with considerable occupational health experience can recall many examples of workers with job-related illnesses whose disorders were accelerated or accentuated by emotional factors. It is just these ancillary items in etiology that the environmentalist should seek out in identifying the cause of untoward physiologic responses. He, like other staff members, can be aware of psychosocial deficits detectable in the acquisition of occupational illness and in the failure to use personal protective devices or to follow precautions advised for hazardous operations.

To do a complete job in protecting the employee against the impinging environment, the environmentalist must be sensitive to sociologic and psychologic pressures, and interweave their effects into those resulting from the more physical challenges to the organism.

That there is resistance to the acquisition of such additional material to the working kit of the environmentalist was given testimony a few months ago when a paper was presented to a meeting of industrial hygienists on the significance of mental health to his relationships with employees and to the successful completion of his professional responsibilities. Approximately one-quarter of the audience left at the completion of the paper just preceding. Is the environmentalist apprehensive about learning in this area? Is it, as he perceives it, completely foreign and unrelated to his functions? Or, does he truly believe that what he does at the industrial scene is something totally apart from the human beings he is involved with

in an instrumental sense? As more voice is currently being given the environment by government, laymen, and ecologists and planners, the industrial hygienist, the health physicist, and the engineer will learn that each is intimately involved with the behavior of man in his roles of despoiler, worker, and community citizen.

What Are the Roadblocks?

What is the basis for the slow pacing of mental health programs at the worksite? Apart from ignorance, fear, or "weakness," in the employee which makes him reluctant to share his concerns, are the medical personnel apprehensive that, in the process of program activation and execution, there will be a disclosure of their own psychic problems? Do they believe that it is too late to acquire this additional body of knowledge?

Is one-to-one personal confrontation an uncomfortable or disturbing experience for those unused to psychodiagnosis and counselling? Do they believe that there is no time for this kind of program in a full day of examination, treatment, and consultation? Whatever the reason offered, successful mental health activities have been born and nurtured to productive maturity once there is realization that one's job satisfaction can be increased by this supplement of understanding.

Essence of the Effort

The only method to be used in initiating this element of an occupational health undertaking is to act supportively, and to be warm, welcoming, and compassionate with employees in need. From this attitude can grow the deep concern with the mental health of those whose health, effectiveness, and happiness it is your rare privilege to hold in stewardship.

APPENDIX A

Questions presented by mail to NASA key medical and environmental health personnel:

1. Is there any formal effort to identify problems of behavior or emotional ill health among NASA personnel at your installation?
2. Do any of you utilize the services of mental health professionals, such as psychologists, psychiatrists, or psychiatric social workers?
3. Are your physicians or environmental health personnel sensitive to changes in mood, thought, or behavior in employees?
4. Do you feel that one group of workers presents more problems in this area than others, e.g., engineers, administrators, flight personnel, maintenance workers, or any other group?
5. Can you recall a specific instance of impaired functioning because of personality difficulties? If so, could you provide a single paragraph abstract of such a case illustration?
6. To those of you in environmental health, do you believe there is any relationship of behavior to performance, as you have seen workers observe, or fail to observe, precautions in health hazardous areas?
7. Has any program ever been attempted in occupational mental health and failed? If so, why did this happen?

8. Would you value any specific assistance in establishing a program in this area, whether it is attempted as such, or is insinuated into the ongoing medical activity?
9. Have any sensitivity training, T sessions, or group discussions ever been held among supervisory personnel, even if these were conducted under the auspices of departments other than the medical facility?
10. With your knowledge of industrial establishments in manufacturing, research, government, or commerce, would you say that personnel at your installation present more problems than workers in these other undertakings?

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LABORATORY HOOD DESIGN

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The potential hazards to laboratory personnel are obvious when we realize that, depending on the substance involved, combustible gas and vapor concentrations over the range from 0.6 to about 10% will produce explosive mixtures, as will fine combustible dusts in concentrations over 20 milligrams per liter of air. The concentrations of toxic materials which will produce damage to the human body are much smaller and threshold limit values (TLV) for such substances as published by the American Conference of Governmental Industrial Hygienists are expressed in parts per million. Nickel Carbonyl, for example, because of its potential carcinogenic effect, has a TLV of 0.001 ppm. Even much smaller limits are applied where radioactive materials are involved; for example, the threshold limit value for Iodine ¹³¹ is 4.5×10^{-12} ppm. In addition to such materials of known toxicity where actual industrial experience has been attained, there are many materials now in laboratory stages of development where no toxicity data or real experience has been acquired. The need for adequate control to prevent exposures to laboratory personnel to all of these classes of materials is evident, and for all practical purposes, laboratory hoods are the means by which this control is attained.

The prime purpose of any hood, therefore, is to protect the operator, and this point cannot be overemphasized. Any design which interferes with good control should not be tolerated, for safety would

be sacrificed. The operator has the right to assume that the hood provides the control needed and he will take liberties in his work that would not be taken if a hood was not available. It follows, therefore, that a poorly designed or improperly operating hood can create a higher hazard level than normally anticipated.

The adequacy of control is based on maintaining a good control velocity across the entire face of the hood. What this velocity should be is subject to the location of the hood within the laboratory, the interferences that exist from such sources as traffic, drafts from windows or doors, make-up air grilles, as well as the type of operation conducted within the hood. Many investigators have reviewed the criteria for control velocities based on containment of materials within the hood when interferences outside the hood are not a factor. Viles has shown that based on the molecular diffusion forces of gases and the particle kinetics (where particles ten microns and less are considered) a velocity of less than 50 fpm would assure containment. It is the other forces outside of the hood, therefore, that determine what face velocities are required.

To give some perspective to the air velocities encountered in laboratory areas, a draft from an open window may vary from 5 to 15 miles per hour (570-1700 fpm), a person walking by a hood at a normal pace travels at a rate of 3 mph (340 fpm), while most hoods have face velocities of 100 fpm or less (1.14 mph). And in fact 100 fpm is normally considered high.

However, there has to be some base lines for recommended hood face velocities. At M.I.T. we have found that if hood locations are satisfactory, outside interferences are minimal and the materials used are not extremely toxic or radioactive nor dispersed at high velocities, a minimum average face velocity of 80 fpm is required. We also stipulate

that the velocity at any point cannot deviate more than 10 fpm from this average. In the case where highly toxic materials such as beryllium, nickel carbonyl, or radioactive compounds are used, the minimum average face velocity recommended is 100 fpm with no point in the face varying by more than 10% from this average.

When hood locations are not ideal, or special operations are involved, each case is individually appraised. It should also be stated that excessive face velocities are not desirable, particularly in areas with more than one hood, for this increases the need for make-up air which causes higher air turbulence within the room with subsequent increase in air disturbance at the hood face.

As stated previously, the velocity balance across the face should be maintained. The flow should be essentially perpendicular to the face opening. This balance is not obtained in the usual fume cupboard, where most of the air enters the top section of the hood with little control at the bench level. To attain balance, a slotted baffle and plenum is used in conventional hoods. Such a design should assure that a constant and uniform negative pressure is maintained in the plenum so each slot will exhaust its proportional amount of air. Good design usually results in slot velocities of 700-1400 fpm. A large number of slots can reduce turbulence within the hood, however, two and three slot hoods are common and this compromise is usually made so the slots can be made adjustable. This permits adjustment to handle high evaporative rates or overcome equipment blockage in the hood.

There are many hoods which are variations of this basic design. These include those with airfoil inlets, vertical sliding sashes, horizontal sliding sashes, bypass types, and constant velocity hoods.

Airfoil inlets reduce air turbulence within the hood by eliminating or minimizing vortices which occur particularly at the hood edges. These airfoils usually allow space for mounting service fixtures thus eliminating the need for having them inside the hood or as projections below the bench surface.

Simple vertical sash hoods are very common and the sashes are often used as safety shields. They have one serious drawback in that as the sash is lowered, the air velocity increases and this can present problems. Horizontal sashes are often used to reduce the overall face opening of the hood and thus lower the total air flow requirement. Such sashes should be mounted in a single track so the total open area is constant. They should be capable of movement so that all areas of the hood are accessible. We have found that this type of hood requires frequent checking, for operators are apt to remove such sashes and leave them out which means of course the proper control velocity at the face is no longer maintained. These hoods present some problems in assuring that all areas of the hood receive proper ventilation. To help overcome this, we have designed sashes so that each has an open area and this is usually at bench level.

Bypass hoods are usually of two types, those that open and allow air to enter right into the exhaust duct or exhaust plenum, and those that open above the sash allowing air to enter the hood proper. In the latter as the sash is lowered to a certain height above the bench, air starts to bypass into the hood chamber. This type of bypass can result in a face velocity increase of over threefold when the sash is lowered.

In recent years there has been a growing tendency to provide year-round air conditioning in laboratory areas. Because of the economics involved, architects and building planners began looking for ways in which the conditioned air loss could be modified. This is certainly understandable for

most hoods require 1000 cfm or more for proper control and it has been estimated that each 200 cfm of air exhausted requires one ton of refrigeration capacity, costing about \$1,000. To this, it was necessary to add from \$50 to \$75 per ton for operating costs annually. This need provided the impetus necessary for hood manufacturers to design and build "supply air" or "auxiliary air" hoods. Unfortunately, many manufacturers lost sight of the main purpose of a hood, that is, to protect the operator, and many of the methods proposed to save air-conditioned air resulted in potentially unsafe hoods.

In the early 1960's, we were asked by our building design group to evaluate commercially available supply air hoods. The criteria that was set before this review was that any supplied air hood design must

- 1) in no way compromise the basic purpose of the hood, which is to provide the operator with adequate protection under all operating conditions and
- 2) that the percentage of supply air must be sufficient (70% or more) to make its use economically feasible. At that time, none of the commercially available models reviewed could meet these requirements. It was then agreed that we would attempt to design an acceptable auxiliary air hood.

To make sure that we as Industrial Hygiene Engineers did not violate the number one rule mentioned previously, it was agreed that:

- 1) all make up or supply air would be provided outside of the hood face;
- 2) the supply air velocity and flow pattern would not affect the face control velocity; and, 3) that supply air could not result in displacement of contaminated hood air by carrying it back into the room.

Many supply systems were tried using lateral supply plenums, overhead plenums, combinations of overhead and lateral supply and eventually a design was developed that was applied to a sixteen hood installation in our Radioactivity Center. The supply system consisted of an overhead plenum

which extended out from the face of the hood and tapered sides which extended from the plenum to the edge of the bench.

The plenum contained a slotted baffle plate, and two perforated plates with offset holes to obtain the balance desired. Dust-stop filters were installed as a means of "knocking out" the velocity as the air passed through the last hole plate.

With this design, it was possible to exhaust these hoods so as to maintain a velocity of 100 fpm at the hood face, supply 75% of the air being exhausted without interfering with the control velocity, and to entrain and exhaust over 90% of the air being supplied.

The air supplied is tempered during the cold weather months for as indicated during our studies, if incoming air temperatures were more than 5°F below room air temperatures, it became uncomfortable for the operator. During warm weather months however, differences as much as 20°F higher than room air have been experienced without complaints and without effect on overall hood performance. In this particular installation, two-speed exhaust fans were used. When the sash is lowered, a sash-operated switch automatically reduces the exhaust fan to low speed and shuts off the supply air system. By use of this technique, overall building balance is maintained because the same amount of room air is exhausted at all times. Filters were required in these systems and dampers were provided in each line and a manometer was installed across the damper and filter. This made it possible to impose "end filter resistance" preventing excessive hood flows when filters are clean. Dampers are adjusted manually to compensate for filter loadings. This system has performed very well aerodynamically with the only complaint being that the canopy was somewhat noisy. Some minor changes in the design have been recently tried on one unit and the noise problem minimized.

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Following this installation, additional investigations were conducted in a study sponsored in part by one of the major hood manufacturers. A new supply air hood was developed. This hood meets the same basic criteria reported earlier. Some of the improvements include airfoil sides and a special deflector plate (a pressurized bottom airfoil).

This hood has been tested at face velocities of from 60 to 150 fpm and at each of these exhaust volumes the supply air percentage has been varied from 50% to 75%. Under all of these conditions, the hood will capture and entrain the supply air at percentages greater than 90%.

With the special deflector plate which introduces less than 4 cubic feet per minute through the special perforated area, a sweeping effect is always maintained at bench level.

Special tests were conducted which indicated what would happen under imbalanced conditions. The exhaust volume was first set to provide an average face velocity of 100 fpm. The supply air was then set so as to provide 70% of the air exhausted. The exhaust volume was then cut back to a point at which the supply air now being provided was actually 100% of that being exhausted. This is the type of condition that might occur if for some reason the fan belt on the exhaust fan slipped or the fan became corroded. Under these conditions, some of the supply air was lost to the room, however, none of the air from within the hood that would represent contaminated air was entrained or displaced in any way so that it was carried out into the work area. This test was conducted using a specially designed uranine aerosol generating and sampling set up. This set up required nine (9) small generators placed across the face of the hood and located six inches back from the actual face. The air samples were then taken just outside of the hood and at various places throughout the laboratory. No evidence of contamination was detected. The hood was

then set up so that again 70% of the air was being supplied and the face velocity of the hood maintained at 100 fpm. A small particle size uranine aerosol was then introduced into the supply air stream at a point just beyond the supply air fan. Air samples were then taken at the discharge channel, and in the exhaust plenum. Using the uranine fluorometric technique, the hood was found to be operating at 96% efficiency. That is 96% of the air being supplied was being entrained and exhausted. This same test was conducted using varying percentages of supply and exhaust. The entrainment efficiency was found to be greater than 90% over the entire testing range.

A total of 50 of these hoods were provided in our new Life Sciences Building. These hoods have been in operation about 3 years and acceptance by laboratory personnel has been gratifying.

A commercial model of this design is now available. The commercial model shown has side extensions which if used can slightly increase the percentage supply possible.

Some of the advantages of this type of supply air hood are worth mentioning. Because there is a protective air curtain of clean air just outside of the hood face, the operator is essentially always protected. Any momentary disturbance of the air patterns in the immediate area of the hood would disturb the supply air curtain, but would not disturb the control velocity at the face of the hood. Although I originally thought that a supply air hood could not be made as safe as a conventional laboratory hood, I now feel that a well-designed supply air hood is a better hood than a conventional exhaust hood.

There are many other fairly new innovations that I feel should be made standard on laboratory hoods. For example, I would like to see all laboratory bench tops be of the recessed type. This would do much to

keep spilled materials from coming out of the hood. If this recess started at a point several inches within the hood, this would make all operators keep their equipment well within the hood face, which in turn would reduce the effective vortices which occur directly in front of the operator when air is coming around him. It should be standard practice today to have an airfoil inlet. Certainly the advantages outweigh the slight difference in cost. All interior surfaces should be easily cleanable and all of the service controls should be located outside of the hood face.

I think it is imperative that those concerned with hood installations do everything that they can to make sure that they get the best operating hoods and hood systems possible. The best way to achieve this is to have the most stringent specifications possible and a performance test should be included. Many of the performance specifications today are based on smoke studies. Smoke tests can be satisfactory. However, the evaluation is such that it is really a judgment decision. It would be much better, therefore, to have such performance tests based on a scientific evaluation. This type of specification could be written involving the uranine test discussed earlier in this paper. Specification should also be written for duct work material, types of fans, fan ratings, and overall noise level. Today while we are spending millions of dollars for laboratory facilities for our teaching and research personnel, I think it is only "just" that we provide for them as complete and perfect a system as possible.