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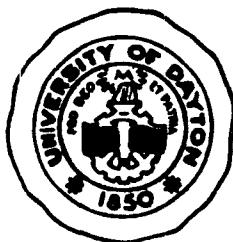
EXPERIMENTAL EVALUATION OF INTERNATIONAL STANDARD (ISO 2631-1974) FOR WHOLE-BODY VIBRATION EXPOSURES

**By
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G.J. Landrum
Eugene Reardon**

December 1976

**Final Report to the
National Institute of Occupational Safety & Health**

Grants 5 RO1-OH-00479-01, 02 & 02S1



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16. Abstract (Limit: 200 words) A study was conducted to evaluate systematically the current International Organization for Standardization (ISO) international standard (ISO-2631-1974) for human body exposure to whole body vibration with particular reference to the range 2 to 16 hertz (Hz) and exposure durations from 16 minutes to 8 hours. Eight male university students participated in the study which employed the Western Gear mechanical vibration machine. The primary performance measure used in this study was a one dimensional, horizontal, visual compensatory tracking task. Additional performance tests measured not only tracking but also attentional selectivity, auditory vigilance and visual acuity. Attentional selectivity was measured using a modified version of the Hockey visual detection task. Also measured were kinesthetic sensitivity, manual dexterity, flicker fusion apparatus, dynamometer, and the Landolt broken ring test. Overall, a total of 14 tests of central or peripheral performance and physiological state were performed. The authors conclude that the ISO standards are overly protective and may unnecessarily restrict human work function if applied in industry, particularly for longer durations of exposure typical of the working day.

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SECTION 1

INTRODUCTION

The occupants of any moving vehicle are subjected to some degree of vibration, both as a result of the vehicle's propulsion machinery and the vehicle's interaction with the ground or the medium through which it travels. It has been well documented that whole-body vibration can, if of sufficient intensity, produce decrements in human performance. (For reviews, see Grether, 1971; Guignard, 1972; Shoenberger, 1972.) It is also known that vibration is most disruptive at those frequencies which correspond to maximum body resonance (Guignard and Irving, 1960; Chaney and Parks, 1964; Shoenberger, 1970) and that at any given frequency the magnitude of the disruptive effects tends to be proportional to the intensity (Harris, et al., 1964; Weisz, et al., 1965). Furthermore, it is known that the disruptive effects are dependent upon such factors as the direction in which the vibration is transmitted to the body (vertical, transverse, or longitudinal), the nature of the task, and the duration of exposure (A'Harrah, 1963; Holland, 1967).

Although much human vibration research in recent years has been directed towards military problems, many of the research findings are equally applicable to nonmilitary, industrial problems in vehicles and workplaces. A knowledge of human safety and performance limitations under vibration enables the industrial engineer or planner to provide working environments which minimize interference with human wellbeing or efficiency.

While a substantial body of scientific knowledge is available concerning the human response to vibration, the multiplicity and varied quality of methodologies and findings has made the understanding, integration and practical application of knowledge in this field difficult. Because of these difficulties, a working group of the International Organization for Standardization (ISO) was established in 1964 to develop human vibration standards. This group (now Subcommittee ISO/TC 108/SC4), established the current International Standard, "Guide for the Evaluation of Human Exposure to Whole-Body

Vibration" (ISO 2631-1974). This standard by international consensus integrates a substantial body of human vibration response data into a usable framework, serving as a guideline for regulating human vibration exposure. It defines specific vibration boundaries, for each of the three principal directions (x, y, z-axis) in which vibration may be transmitted to man in the frequency range 1 to 80 Hz and for notional daily exposure durations from 1 minute to 24 hours. These boundaries are defined in terms of rms acceleration above which there is deemed to be a significant risk that some undesirable effect will occur. The boundaries are defined in the ISO Standard according to three main criteria and are named:

1. Fatigue-Decreased Proficiency Boundary;
2. Exposure Limit; and
3. Reduced Comfort Boundary.

The Fatigue-Decreased Proficiency (FDP) Boundary represents the limiting values of acceleration above which human task performance is deemed likely to deteriorate. Thus, provided the individual is not exposed to vibration of greater severity than that associated with the FDP Boundary, it is presumed that the individual can perform a given task just as well with or without vibration. If vibration intensity exceeds the limiting value there is, according to the Standard, a significant risk that an individual will perform the task less proficiently than he would if not exposed to vibration.

Both the "Exposure Limit" and the "Reduced Comfort Boundary" are defined in relationship to the FDP Boundary. The rms acceleration values associated with the Exposure Limit are 6 dB (x2) higher than those for the FDP Boundary while the rms acceleration values associated with the Reduced Comfort Boundary are 10 dB (approximately x3) lower than the corresponding FDP Boundary values. The Exposure Limit and the Reduced Comfort Boundary were associated with the FDP Boundary in this fashion for two reasons. First, the available data concerning performance consequences of vibration at various frequencies and exposure durations was

much more plentiful. It was deemed reasonable by the drafters of the standard to assume that the established relationships between hazard and performance and between comfort and performance which has been found at certain frequencies would follow similar patterns for the same ranges of frequency and exposure duration primarily investigated for performance decrements. The second reason was of an administrative nature. An overly complex standard, which is difficult to interpret and conform to, is of uncertain practical value and unlikely to win acceptance in industry. By incorporating this simple relationship between the three boundaries, the ISO produced an interim standard that is easily understood and in reasonable conformity with previously available data.

The Exposure Limit indicates those vibration intensities above which there is deemed to be significant risk to the health and safety of the individual. That limit may be applied to protect man against potentially hazardous levels of whole-body vibration. The Reduced Comfort Boundary establishes vibration intensities above which the individual is likely to experience discomfort, e. g., when riding in vehicles as a passenger.

When the ISO established this Standard (in support of which the United States was one of the member-countries casting an affirmative vote), they encouraged their members to promote research activities in their respective countries for the purpose of collecting further and better human vibration data to be used in the revision and improvement of the Standard. The Standard has already been adopted as a law or regulation in several countries, governing permissible levels of vibration in working vehicles, work places, and other situations. In the United States, several agencies, including the Armed Forces, have given the Standard varying degrees of recognition as a guide for permissible human vibration exposure. Although there is as yet no binding vibration standard for human exposure in American industry, the National Institute for Occupational Safety and Health (NIOSH) has considered the need for such a standard (Wasserman & Badger, 1972). Obviously, if the ISO Standard is to be considered for adoption as the basis of a national

industrial standard, it is particularly important that it be adequately evaluated both in the laboratory and in the workplace, and if necessary, its validity established prior to such adoption. A vibration exposure limit which is not sufficiently stringent, for example, might expose industrial workers to unacceptable hazards resulting from impaired performance. Conversely, an overly conservative standard would be economically wasteful to comply with and could unnecessarily restrict man's work functions. Possible revisions of the standard, based on new and better data, could involve both increasing permissible acceleration at some frequencies and durations and decreasing it at others.

Cogent criticism concerning the standard has been voiced, particularly regarding the meagerness of the data upon which the levels are based as functions of frequency and duration, as well as the assumptions implicit in the standard concerning the relationships between man's subjective response and his physical tolerance of vibration stress. Data serving as a reliable basis for estimating human vibration exposure limits for long duration exposures (more than one hour) are particularly scanty, for most previous research has involved short-term human exposure (Guignard, 1972).

The purpose of NIOSH support (grants 5 RO1 OH-00479-01, 02 and 02S1) was accordingly to evaluate systematically the current International Standard (ISO 2631-1974) on human exposure to whole-body vibration with particular reference to the range 2-16 Hz and exposure durations from 16 minutes to 8 hours.

SECTION 2

EXPERIMENTS

2.1 PHASE I - LOW-FREQUENCY SHORT-TERM EXPERIMENTS

2.1.1 Methods

2.1.1.1 Subjects and Training

Eight male university students between the ages of 18 and 21 were selected as members of the subject panel. In order to qualify for participation, subjects were required to provide a detailed medical (see Appendix D for Subject Application) and vibration history and be examined by a physician familiar with vibration hazards. Certain conditions (e.g., a history of back trouble or other conditions at the discretion of the examining physician) excluded applicants from selection. Upper jaw dental impressions were also taken (James T. McMillin, DDS, Enon, Ohio, and Charles A. Jordan, DDS, Kettering, Ohio) and used in fashioning mouthpieces which were worn by subjects during the experiment in connection with monitoring vibration transmitted to the head.

The subjects' voluntary informed consent was obtained with respect to all aspects of the experimental program. Current Air Force Aerospace Medical Research Laboratories (AMRL), University of Dayton and pertinent Department of Health, Education, and Welfare (DHEW)/NIOSH regulations were fully respected in this connection. Furthermore, the experimental procedures were reviewed and approved as nonhazardous by both the University of Dayton Committee for the Protection of Human Subjects and the AMRL Human Usage Review Committee (because experimentation took place in AMRL facilities). (See Appendix C for Experimental Protocols.)

Subjects were reimbursed on an hourly basis for all periods of attendance, including qualification, training, and experimentation. Before participating in an actual testing session, subjects received two

four-hour training sessions, during which time they were familiarized with the apparatus, the vibration frequencies used during experimentation, and all of the testing procedures involved in a regular testing session. During these sessions they received a minimum of six hours of training on the psychomotor tracking task and sufficient training on all other performance tasks to minimize learning effects during experimentation.

2.1.1.2 Test Facility

The Western Gear mechanical vibration machine, located in Building 93, Area B, Wright-Patterson Air Force Base, Ohio, was used to produce the required 2, 4, and 8 hertz vertical sinusoidal (a_z) vibration used during this phase of experimentation. The Western Gear vibration platform is elevated approximately 1.2 m from ground level and has a top surface measuring 1.1 m square. A stationary (nonvibrating) wooden platform standing 1.2 m tall and measuring 2.4 x 3.7 m completely surrounded (without touching) the vibration platform to permit subject access. Fixed to the surrounding platform were five 1.2 x 1.8 m sheets of tempered masonite paneling, forming an enclosure which isolated the subject visually from experimenter movement and other potential distractions within peripheral visual field. The masonite panels were situated such that the one directly facing the subject was 1.5 m from his resting eyepoint. The remaining panels formed a semicircle around the subject at a distance slightly greater than 1.5 m. A sixth panel was mounted 0.6 m directly behind the vibration platform for use during a performance task.

The vibration seat and console, which were designed and constructed by University of Dayton Research Institute staff, consisted of a rigid, tractor-type steel seat, handgrips mounted on a midline steel central column, a left footrest and right footpedal. The arrangement is illustrated in Figure 1. The footrests, footpedal, and central post were adjustable incrementally to accommodate the leg and arm lengths of different subjects. The footpedal, a spring-loaded pedal, designed to be depressed and released much like an automobile accelerator pedal, was used for the tracking task.

Key

- A Seat fixed to base
(vibrated platform)
- B Midline column carrying
bicornuate handgrips.
Distance AB is adjustable
to fixed settings.
- C Left and right footrests
(right is pedal for the
tracking task). Distance
AC is adjustable to fixed
settings.

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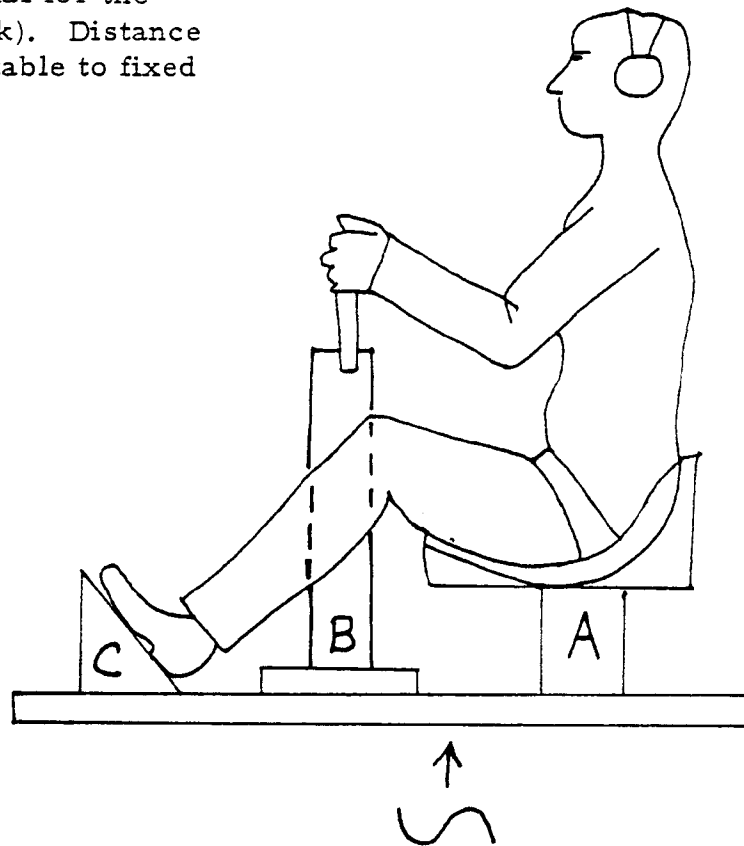


Figure 1. Schematic Diagram Showing Subjects' Riding Position for UDRI Vibration Experiments (Lateral View).

Mounted on top of each handgrip was a thumb-activated push button switch for use for visual and auditory secondary tasks. The seat, central post, foot rest, and footpedal were rigidly mounted upon a 109 x 61 cm aluminum plate which was bolted to the vibration platform. Subjects were secured into the vibration seat with a seat belt incorporating a strain gauge, which enabled the experimenters to standardize and monitor seat belt tightness during experimental runs (see Appendix F for schematic).

2.1.1.3 Experimental Testing Apparatus

Tracking. The primary performance measured used in this study was a one-dimensional, horizontal, visual compensatory tracking task. The apparatus for this task included three major components: a forcing function, a visual display and a control device. The forcing function was white noise recorded on magnetic tape. The 20 x 15-cm display, resembling a speedometer, was mounted at eyelevel on the panel immediately facing the subject, with respect to whom the pointer moved in a coronal plane. The control device in this task was the right footpedal previously described. The sum of the voltages from the forcing function and a variable resistor attached to the control device represented error in the system. When zero tracking error was present, the pointer was centered on the meter display. Deviations to the right and to the left of the center represented positive and negative error. The subject's task was to minimize error in the system by means of the footpedal. Specifically, the appropriate response to positive error was to reduce pressure on the footpedal while the appropriate response to negative error was to increase pressure. Subjects were always able to override the forcing function voltage by adjusting the footpedal. Both negative and positive error were automatically digitized and accumulated (see Appendix F for task schematic).

Hockey Test of Attentional Selectivity. Attentional selectivity was measured utilizing a modified version of the Hockey visual detection task (Hockey, 1970). The display consisted of ten 12 v lights, each encased in a one-inch diameter jeweled lens. The lights were mounted on top

of ten black stands which stood, approximately at eyelevel, 1.45 m above the vibration platform. The lights were symmetrically arranged to the left and right of the tracking display at 20°, 35°, 50°, 65°, and 80°. Each light was 1.5 m from eyepoint, thus making both the tracking display and the lights equidistant from the subject's eyepoint. The lights were automatically activated, one at a time, in a predetermined subjectively random sequence by tone bursts recorded and played on magnetic tape utilizing a Hewlett-Packard instrumentation tape recorder. The subject was instructed to cancel each light using the pushbutton switch on top of the right handgrip. Each light was cancelled automatically after six seconds if the subject failed to respond. The occurrence of a light, cancellation reaction time and the number of lights missed by subjects were recorded automatically (see Appendix F for task schematic).

Headgear and Chest Electrodes. The frequency and intensity of the vibration transmitted to an arbitrary point on the head of each subject was measured using a lightweight piezoresistive accelerometer (ENDEVCO Model 2265-10) firmly attached to individually fitted plastic upper-jaw dental molds worn by each subject. A Sanborn analog strip-chart recorder was used to record periodic samples of the waveform, frequency and intensity of the vibration transmitted to the subject's head, in order to verify stability of the vibration input to the subject throughout each run. The system was calibrated each morning prior to experimentation.

In addition to the mouth-mounted accelerometer, subjects were required to wear padded earphones (Koss type KO/727B) through which 80 dB (A) masking white noise was presented and through which the experimenters could communicate with subjects. Subjects also wore three electrocardiogram (EKG) electrodes, from which heart rates were monitored by means of a portable Sanborn electrocardiograph. *

*Nonstandard chest leads (presternal recording and lateral indifferent electrodes) were selected to minimize vibration artifact in the EKG.



Figure 2. Headphone and Mouthpiece Position (Photo).

Kinesthetic. Testing Kinesthetic Sensitivity was measured using two aluminum bars, each having seven slots cut into one side of the bar. The two edges of each slot were parallel, with the areas between slots being perfectly smooth. One bar measuring 28 cm long and having slot sizes ranging from 2.5 cm to 0.318 cm was used to test kinesthetic sensitivity of the palm. A smaller bar measuring approximately 23 cm long was used for determining finger sensitivity and had slots ranging in size from 0.635 to 0.020 cm.

Manual Dexterity. This was measured using the Lafayette One-Hole Test (Model 32036). The one hole test consists of a wedge shaped box with a dished tray at the bottom front and a small hole on the top. A chrome plate extends approximately five cm from underneath the box for the purpose of providing electrical contact between the test device and the subject's hand not in use. Seven pins were contained in the device with an eighth pin resting in the dished tray. As one pin was removed from the tray and inserted (positioned) in the hole, another pin slid into its place. The contact between the subject's fingers and the tray activated a clock which registered cumulative grasp time. Likewise, contact between the hole and the subject's finger ran a separate clock which measured cumulative position time.

The kinesthetic and manual dexterity tasks were administered on a table conveniently close to the vibration platform.

Flicker Fusion Apparatus. The apparatus (Lafayette Instruments Model 12020) consisted of viewing tube and a flash-time rheostat. One end of the viewer consisted of a shielded eyepiece through which the subject observed two patches of light flashing in the rear of the viewer. The patches of light flashed simultaneously and could be adjusted, with the rheostat, to a speed of 30 to 128 flashes per second. The flicker fusion viewer was on a 1.45 m stand, approximately eyelevel to the seated subject. The subject's critical flicker fusion rate was measured and recorded. (See Appendix E, Exhibit J for procedure.)

Dynamometer. Grip strength was measured using a metal hand grip comprising two concentric rings. As the rings were gripped, a dial in kilograms recorded the force exerted (Lafayette Instruments Model 78010).

Landolt Broken-Ring Test. To prevent accommodation during this test of visual resolution acuity, it was necessary to provide a light path of 6 meters despite limited space. Obtaining this distance required the use of a mirror which hung 2.7 m in front of the subject, and was positioned

to reflect the visual stimulus located on the back panel, 60 cms behind the subject. The 41 cm square mirror, which was front silvered to avoid spurious reflections, was hung approximately 30 cms above the subject's eyelevel, beyond the enclosure positioned directly in front of the subject. A trap door located directly above the tracking display was opened periodically to reveal the mirror and visual stimulus. Visual acuity was measured by means of a modified version of the Landolt Broken-Ring Test of Visual Resolution Acuity (Landolt, 1889). The broken rings were photo-printed on 30.5 cm square cards in four 3 x 3 arrays. Thus, each card contained 36 broken rings. The size of the rings on a given card were identical; however, cards with ring sizes corresponding to a range of visual acuities (20-15 to 20-65) were used for different subjects.

2.1.1.4 Procedure

The experimental procedure was divided into two parts consisting of: (a) performance tasks and subjective ratings measured during vibration and control sessions and (b) psychophysiological testing which occurred before and after each session. Subjects were requested to avoid excessive noise, strenuous activity, alcohol or drugs of any kind for 24 hours prior to experimentation (see Appendix E for Subject Instructions). No subject was scheduled for more than one testing session within any given 48-hour period. Subjects had their own testing schedule and arrived at the same time for each experimental run. Subject runs were cancelled if illness, lack of sleep, or any other condition appeared in the experimenter's judgment to render a subject unfit. After the beginning of a test session, discussion about the experiment was discouraged and no feedback, either verbal or nonverbal, was given during run regarding their performance. Subjects were neither encouraged nor discouraged from expressing positive or negative opinions about the experiment. The experimental procedure included the following sequence of activities.

Electrode placement and urine sample

Pretests:

Kinesthetic test

Manual dexterity test

EKG reading

Subject boards vibration seat

Pretests:

Flicker fusion test

Vasomotor test

EKG reading

Grip strength (dynamometer) test

Vibration turned on (except during control runs)

Performance tasks and subjective ratings measured during vibration (and control) runs:

Tracking task

Hockey task

Task difficulty rating

Visual acuity task

Motion severity rating

Vibration turned off

Post-tests (identical to pretests) and urine sample

Electrode Placement and Urine Sample. Before the beginning of an experimental session, the three self adhesive EKG electrodes were applied to subjects, two over the sternum and a third under the left arm. This procedure usually required temporary removal of the subject's shirt. Subjects were next required to provide a urine specimen. All specimens were analyzed within 24 hours (Dille Laboratories, Dayton), primarily for blood and protein.

Kinesthetic Testing. This test was administered with subjects seated at a table. The experimenter took the subjects right hand and gently rested the hypothernar eminence on one of the slots contained in the larger kinesthetic bar. The subject was instructed to respond by saying "yes" if he felt two edges and "no" if he did not. The test always began with a large slot having easily recognizable edges and then proceeded to consecutively smaller slot sizes until the subject responded "no". That slot position (1 = smallest slot to 7 = largest) was then recorded and the experimenter continued the test by placing the subject's palm on a slot

small enough to insure a "no" response. The palm was then positioned to successively larger slots until the subject again responded "yes". This position was then recorded and the procedure was repeated until three "yes" and three "no" responses were obtained. This procedure was then repeated with the right index finger, the left palm, and the left index finger. The responses for each test were averaged resulting in four sensitivity scores, one for the right palm and right finger and one for the left palm and index finger.

Manual Dexterity. Subjects remained seated for the Manual Dexterity Test. The test device was positioned in front of the subject with the tray positioned to the right or left of center depending on the subject's dominant hand. The free (nondominant) hand rested on the chrome plate in front of the tray and the dominant hand was held in readiness above the exposed pin in the tray. Subjects were required to grasp the exposed pin and place it into the hole on top of the test device and continue placing pins into the hole as rapidly as possible for one minute. The experimenter signaled the beginning of this 60-second test by saying "ready, begin", and the end by saying "stop". The number of pins, grasp and position times were recorded.

Electrocardiograph Recording. Following the Manual Dexterity Test, subjects were asked to walk to the EKG monitor and stand quietly while the experimenter connected and recorded a 30-second EKG to check for proper electrode placement and to obtain a baseline waveform and heartrate. Subjects were then lead up the stairs onto the vibration platform, seated and belted onto the seat. The seatbelt was tightened to a standard tension of 13.6 kg for all times. The remaining pretests were performed with the subject seated and belted in the vibration seat.

Flicker Fusion. The viewer was placed within easy reach of the subject for this task. Subjects were instructed to look into the eyepiece and to attend closely to the two patches of light inside which

were initially adjusted to 30 flashes per second, producing an obvious flicker. The experimenter then began to speed up the flash time until the subject could no longer detect any flicker or movement in the light patches. Subjects reported the disappearance of the flicker by saying "now" and the flicker rate was recorded. Flicker rate was then immediately increased to 128 flashes per second which insured the absence of any detectable flicker. Flicker rate was then slowly decreased until the subject again detected a flicker which he reported again by saying "now". This flicker rate was then recorded. The above procedure was repeated twice and the scores averaged producing an average flicker fusion rate.

Vasomotor Test. This test was included to look for possible alterations in peripheral vasomotor tone resulting from vibration. To obtain this measurement, the experimenter exerted firm pressure for a few seconds with his thumb on the back of the subject's hand. The return of normal skin color (fading of pallor) was then timed using a stopwatch. Three responses were timed (secs) and averaged for each hand. Following the vasomotor test, a 15-second EKG was taken to obtain a resting heart rate prior to vibration, or control, exposure.

Dynamometer. The final pretest was a measure of grip strength. Subjects were required to grip the dynamometer as tightly as possible to obtain a grip strength measurement. This task was repeated twice for each hand and the scores averaged for each hand.

Following the dynamometer test and immediately prior to vibration (or control) runs, the subject was handed the earphones and his dental mold, which he clipped to his upper teeth as instructed. The EKG and accelerometer cables were then taped to the subject's shoulders, in a fashion minimizing cable-swing during motion.

Performance Tests and Subjective Ratings. The vibration or control exposure duration during the first series of (short duration) experiments was either 16 or 25 minutes. Subjects were given a 45-second

warning prior to the beginning of a testing session. This provided sufficient time for subjects to put on headphones, dental molds and to prepare for the performance tests. Ten seconds prior to testing the experimenter announced either "Vibration coming on" or "this is a no-vibration run" depending on the condition. If a vibration run was scheduled, the vibration was turned on immediately following the warning. The following performance tasks were administered during the vibration exposure or control phase of testing.

Tracking. Subjects performed the tracking task for 15 minutes during the 16-minute runs and for 24 minutes during the 25-minute runs. During this task, subjects were required to keep the needle of the tracking display as close to the center position as possible by means of the footpedal. The tracking task was stressed as the primary task, to which the subject was instructed to give his primary attention. The subject was informed that his error score was based on both the length of time the needle was off the center position and how far the needle was off position.

Hockey Test of Attentional Selectivity. The attentional selectivity task was performed simultaneously with the tracking task. The subject was required to cancel illuminated lights as rapidly as possible by pushing the button on top of the right hand grip. He was required to keep his thumb positioned on the button at all times. Each light was automatically activated five times during the 16-minute runs and eight times during the 25-minute runs. Thus, either 50 or 80 stimuli were presented during the session with interstimulus intervals of 10 to 20 seconds. Cumulative reaction time, number of lights cancelled and the number of lights which went undetected were automatically recorded for each light. While performing tracking and attentional selectivity tasks, the subject received 80 dB(A) white masking noise through his headphones, to minimize auditory distraction and to provide an equivalent acoustic environment during vibration and control runs (in which there was no vibrator noise).

Task Difficulty Rating. The tracking and attentional selectivity tasks continued for either 15 or 24 minutes. Then these tasks were turned off and a task difficulty (TD) rating was taken. The 9-point TD scale appears in Appendix E (Exhibit P). For this rating, the subject was asked to rate the subjective difficulty of the tracking and visual selectivity task.

Visual Acuity. Immediately following the TD rating, the trap door above the central display was opened, revealing the mirror and Landolt broken-rings. The size of the rings was selected for each subject (depending on his innate visual acuity) so that the error was approximately 10% without vibration. The subject was instructed to call out each row (1-6) and the clock position (1-12), i. e., the gap orientation, of each ring. The experimenter signaled the beginning of the test and the subject was allowed 60 seconds to complete the test, after which the trap door was closed whether or not the subject had finished the test.

Motion Severity Rating. Immediately following the visual acuity task, the subject was asked to rate the subjective motion severity occurring at that moment. A modified version of a NASA 9-point subjective rating scale, previously used to evaluate the severity of combined stress conditions including vibration (Grether, 1972) was used in this experiment. The Motion Severity (MS) scale also appears in Appendix E, Exhibit T.

The TD, MS, and Visual Acuity Tests took approximately one minute to complete. Following the MS rating, vibration was turned off and the post-vibration psychophysiological testing procedure was repeated. The pre- and post-tests were identical with the exception that their presentation order was slightly different as indicated in the procedure outline.

Accelerometer and EKG Recordings. Accelerometer readings were recorded continuously during vibration runs. Although no recordings were taken during control runs, subjects were required to wear their dental molds to avoid introducing a confound. The relative intensity of the vibration transmitted to the subject's head was monitored by measuring

the width of the vibration trace at eight-minute intervals during vibration. Fifteen-second EKG recordings were also taken thirty seconds after the onset of each vibration (and control) testing session and thereafter at eight-minute intervals. Heart rate was obtained by counting the number of heart beats, within the fifteen-second period, and multiplying by four.

2.1.1.5 Experimental Design

The design utilized for the analysis of performance (tracking, attentional selectivity, and visual acuity), subjective ratings (motion severity and task difficulty), heart rate and urine constituents data was a one-way analysis of variance (ANOVA) with repeated measures on all conditions. There were four vibration conditions (0, 2, 4, and 8 Hz) repeated on eight subjects. The vibration conditions are given in Table I. The physiological data, except for heart rate and urine constituents, was reduced to post-test minus pretest difference scores because our interest was to determine if any particular experimental condition resulted in a significantly greater difference than another. Specifically, we were looking for larger difference scores following dynamic (2, 4, and 8 Hz) conditions than during control runs. These difference scores were analyzed by the same one-way ANOVA with repeated measures. The same subjects were utilized in both 16- and 25-minute runs; however, the data were considered separately.

2.1.2 Results

A complete summary of the Phase I data analysis is shown in Appendix A. Only overall results will be discussed because, as can be seen from Table II, the experiments yielded essentially negative results. Tracking error totals appeared to be higher at 2 and 4 Hz for both 16- and 25-minute runs than during the corresponding control runs, but these differences were not significant. Attentional selectivity likewise yielded no significant differences during 16- and 25-minute runs. Neither visual acuity nor the TD rating data yielded significant results, although numerically higher TD ratings occurred during the dynamic conditions than during control runs. Motion severity

TABLE I
PHASE I - VIBRATION CONDITIONS
(Short Duration Exposures)

Frequency	Exposure Time (minutes)	Fatigue-Decreased Proficiency Boundary (ISO)*
0	16	(---)
2	16	0.306
4	16	0.216
8	16	0.216
0	25	(---)
2	25	0.255
4	25	0.184
8	25	0.184

Note: The vibration acceleration level will be zero during control runs at each duration (the subject will be seated on the vibration platform receiving no vibration).

Appendix E, Exhibit B shows a typical running protocol for pre- and post-vibration testing, Appendix E, Exhibit C gives a schematic chart showing the timing of performance and subjective tests during vibration and control periods.

* ISO 2631-1974, Values listed here are peak "g" at the seat, for vertical (z-axis) motion.

TABLE II
PHASE I - RESULT SUMMARY

MEASURE	VIBRATION CONDITIONS				F- RATIO	SIGNIFICANCE LEVEL (Criterion = .05)
	0 Hz	2 Hz	4 Hz	8 Hz		
<u>Tracking Error</u>						
16-minute total	101.76	112.68	115.65	102.41	1.95	N. S. (not significant)
25-minute total	76.92	83.62	83.68	75.39	1.21	N. S.
<u>Attentional Selectivity</u>						
<u>Total Reaction Time</u>						
16-minute total	2.49	2.46	2.46	2.37	1.68	N. S.
25-minute total	4.13	3.98	4.10	4.10	.63	N. S.
<u>Visual Acuity % Correct</u>						
16-minute means	64	62	62	69	.97	N. S.
25-minute means	76	67	73	67	.76	N. S.
<u>Task Difficulty Rating</u>						
16-minute means	3.50	4.75	4.37	4.25	1.25	N. S.
25-minute means	3.25	4.75	4.50	4.72	5.06	p < .01
<u>Motion Severity Rating</u>						
16-minute means	1.0	4.30	5.30	5.80	23.58	p < .01
25-minute means	1.0	4.10	5.12	5.62	26.90	p < .01
<u>Kinesthetic-Finger*</u>						
16-minute means	- .11	- .12	- .09	- .39	1.23	N. S.
25-minute means	- .02	- .12	- .03	- .11	.19	N. S.
<u>Manual Dexterity*</u>						
<u>Number of Pins</u>						
16-minute means	.33	1.20	5.20	.00	2.71	N. S.
25-minute means	-1.12	-2.25	1.37	-1.25	2.18	N. S.
<u>Flicker Fusion Flash Rate*</u>						
16-minute means	- .18	- .30	- .06	-1.12	2.13	N. S.
25-minute means	-2.80	- .82	-1.76	-1.14	.76	N. S.
<u>Vasomotor Reaction Time*</u>						
16-minute means	- .18	- .30	- .06	-1.12	2.13	N. S.
25-minute means	-2.80	- .82	-1.76	-1.14	.76	N. S.
<u>Heart Rate (last minute)</u>						
16-minute means	73.0	69.3	71.0	74.0	.56	N. S.
25-minute means	77.0	77.2	74.5	75.5	.35	N. S.
<u>Dynamometer*</u>						
16-minute means	- .52	- .65	- .08	-1.46	3.83	p < .05
25-minute means	-1.30	-1.50	+1.64	- .83	2.22	N. S.

*Post-test minus pretest difference scores.

ratings differed highly significantly for both 16- and 25-minute runs with a mean dynamic (vibration) rating of 5.1 compared to a mean static rating of 1.0.

The psychophysiological data revealed no significant differences except for the 16-minute dynamometer results in which the largest difference score was during the 8 Hz condition. This is probably a chance effect, however. A trend, of obscure meaning, was noted in the flicker fusion data, with flicker fusion rates appearing to drop following both dynamic and control conditions. A "t" test comparing all the flicker fusion pretest scores with all the post-test scores revealed a significant overall decrease in fusion rates ($t = 2.45$, $p < .01$), however, decrements associated with dynamic conditions were not significantly greater than decrements associated with control conditions.

The remaining physiological tests, including urine tests and heart rate showed no consistent trends and no significant differences. Equipment failure precluded acceleration monitoring in a number of runs. In those monitored, however, it appeared that seat-head vibration transmissibility remained constant throughout the run.

2.2 PHASE II - LOW-FREQUENCY LONG-TERM EXPERIMENTS

2.2.1 Methods

2.2.1.1 Subjects and Training

A new panel of eight male University students with a median age of 25 years was selected for the Phase II experiments. The procedure for selection, qualification, and training of this new panel was identical with that adopted in Phase I.

2.2.1.2 Test Facility

Phase II used the same test facility as was used in Phase I.

2.2.1.3 Experimental Testing Apparatus

The only change in the apparatus between Phase I and Phase II experiments was the addition of the Wilkinson Auditory Vigilance task (Wilkinson, 1970) which was recorded on magnetic tape and presented to subjects over their headphones. As was our intention, all other apparatus and materials used for the Phase II experiments, including the test locations, were identical with those used during Phase I.

2.2.1.4 Procedure

The procedure for the Phase II experiments was also divided into pre- and post-physiological tests and the evaluation of performance tasks and subjective ratings during vibration (and control) runs. The pre- and post-testing procedure was identical with that employed during Phase I. To accommodate the longer duration runs (2.5, 4, and 8 hours), performance testing sessions were divided into 30-minute blocks. Thus, associated with 2.5, 4, and 8 hour experiments, there were 5, 8, and 16 30-minute blocks respectively (see Appendix E, Series 2: Long Duration Experiments, Exhibit C).

The procedure within each 30-minute block was divided into the following. * For the first five minutes, subjects simply rested in place while seated on the vibration platform and were not required to perform any tasks. Within block procedure was similar to that employed during 25-minute Phase I runs. Forty-five seconds before the end of each five-minute break, the experimenter called out "45" and the subject proceeded to don headphones, dental mold, and to prepare himself for the performance tasks. At the end of the five-minute break, the performance tasks were activated and the subject proceeded to track for twenty-four minutes; provide a TD rating; perform visual acuity for up to sixty seconds; and then provide a MS rating. Thus, the thirty-minute block consisted of a five-minute break, twenty-four minutes of tracking and one minute of visual acuity measurement.

For the 2.5 hour exposure experiments, each block immediately followed the preceding block with subjects continuing to receive vibration (or no vibration) between blocks without coming off the vibration machine. Four- and eight-hour vibration exposure durations contained the following sequence of breaks during which vibration was turned off, subjects were allowed to dismount from the vibration platform, they provided a urine sample and then were allowed to rest. During the four-hour exposures, the subject was given a fifteen-minute rest break between the fourth and fifth block; and for the eight-hour exposures, the subject was given a fifteen-minute rest break after the fourth block, a thirty-minute lunch break after the eighth block, and a fifteen-minute rest break after the twelfth block.

As during Phase I experiments, a secondary task was performed in conjunction with the primary tracking task. Two alternating secondary tasks, however, were employed during the long term experiments including the previously described Hockey (attentional selectivity) task and the Wilkinson Auditory Vigilance Task (Wilkinson, 1970).

*Appendix E, Exhibit C in Series 2: Long Duration Experiments gives a schematic chart showing the timing of tasks during 30-minute blocks.

Wilkinson Auditory Vigilance. The Wilkinson and Hockey Tasks were alternated between blocks such that the Hockey task always occurred during the last block of each experimental session. For example, during the 2.5 hour runs, subjects received the Hockey task on blocks 1, 3, and 5 and the Wilkinson task on blocks 2 and 4.

For the Wilkinson task, brief 85 dB tones (at 1000 Hz), with a tone-to-tone interval of two seconds, were superimposed onto the 80 dB(A) white noise background. The tone duration was ordinarily 0.5 seconds, however occasionally (1 out of every 45 tones at random), a tone of 0.4 seconds duration occurred. This shorter tone constituted a signal to be detected and reported. The appropriate response to a signal was to depress the thumb switch on the left handgrip. If this was accomplished prior to the occurrence of the subsequent tone, it was considered a correct response. This task was scored in terms of number of correct responses, number of undetected signals, and the number of false positives (responding when no signal occurred).

Incentive Program. To increase the subject's motivation to remain attentive to the tracking task on the long-term runs, good performance was rewarded with a monetary bonus. Each subject was informed that he would receive a bonus following completion of the experiment, the size of which was to be determined by how well his tracking scores compared with those of the other subjects. Subjects received between \$15 and \$65 in bonus money for all Phase II runs. Bonuses were paid on three occasions during Phase II runs following completion of all 2.5 hour runs, after completion of all 4-hour runs, and following all 8-hour runs.

2.2.1.5 Experimental Design

Positive, negative, and total tracking error were individually analyzed using a two-way ANOVA in which vibration conditions (0, 2 and 4 Hz) and blocks (5-16) were treated as independent variables with subjects repeated on all conditions. These overall analyses were performed solely to test for main effects of vibration. As in all subsequent analyses,

the main effect of blocks and the interaction of blocks times vibration conditions were not considered. Instead, separate one-way ANOVA's were performed to examine the effect of the vibration conditions within each block. The Hockey attentional selectivity reaction times were analyzed with an overall three-way ANOVA in which the independent variables were conditions, blocks (during which the Hockey test was performed) and light position (20° - 80°) with subjects repeated on all variables. Each light position was then considered individually using a two-way conditions times blocks ANOVA with repeated measures. The Wilkinson auditory vigilance data were first analyzed in a similar overall manner with independent variables of conditions times blocks and then each block was considered separately. Wilkinson testing occurred on alternate blocks as previously described. As in all the other analyses, subjects were repeated on all conditions.

Task difficulty and motion severity ratings were analyzed over all blocks using a two-way condition times blocks ANOVA with repeated measures on both factors and then within each block using a one-way ANOVA. Visual acuity was also analyzed over all conditions and blocks and then within each block. The physiological data were analyzed using one-way ANOVAs in which the independent variables were the difference scores associated with each condition. Heart rate was analyzed over all blocks and then individually for each block, similarly to the performance data. Urine constituents data were analyzed with independent variables of conditions and sampling time with repeated measures on both factors, and then, as with blocks, each sample time was analyzed individually across vibration conditions. Finally the accelerometer data were analyzed by means of a three-way ANOVA in which the independent variables were magnitude of acceleration, blocks and time of sample (nested within blocks) with repeated measures on all conditions. As with the short term data, the data associated with each exposure duration were analyzed separately.

TABLE III
PHASE II - VIBRATION CONDITIONS
(Long Duration Exposures)

Frequencies	Exposure Time (hours)	Fatigue-decreased Proficiency Boundary (ISO)*
0	2.5	(---)
2	2.5	0.144
4	2.5	0.102
0	4.0	(---)
2	4.0	0.108
4	4.0	0.076
0	8.0	(---)
2	8.0	0.065
4	8.0	0.045

Note: Appendix E, Series 2 Long Duration Experiments, Exhibit B shows a typical running protocol for pre- and post-testing. Appendix E, Series 2 Long Duration Experiments, Exhibit C gives a schematic chart showing the timing of tasks during 30-minute blocks.

* ISO 2631-1974, values listed are peak "g" (z-axis) at the seat.

2.2.2 Results

Complete Phase II results are tabulated in Appendix A and the overall results are listed in Table IV. Again, the experiments yielded no significant results between vibration conditions, except for incidental findings within blocks which were expected because of the large number of analyses performed. As in the case of the Phase I results, only overall findings will be discussed. Total combined tracking error was virtually identical between all vibration conditions for all three exposure durations. Overall tracking error appeared to be greater during the Wilkinson task, but this trend decreased during the longest duration runs. The combined Hockey attentional selectivity data were also nonsignificant; however, a numerical trend similar to Phase I data occurred with shorter reaction times occurring during vibration conditions than during control runs. Although on the basis of our analysis this must be dismissed as merely a chance effect, all of the significant findings within blocks showed this trend with 4 Hz reaction times being the fastest and the control reaction times being the slowest.

The Wilkinson data showed no results or trends, with percent correct totals being insignificant. Because of the small differences in the Wilkinson results, the authors did not feel that a signal detection analysis was warranted. The 2.5 hour task difficulty (TD) ratings were significantly different with ratings for 0 and 2 Hz virtually identical and the 4 Hz rating obviously higher. Although the TD rating data were not significant for 4- and 8-hour exposures, the scores followed this same trend with ratings during dynamic runs appearing to be larger than during control runs. These results are consistent with Phase I findings. Motion severity ratings were also higher during dynamic conditions and proved to be highly significant for all durations. This finding is also consistently noted within each block. The visual acuity data yielded no significant differences or trends for any of the experiments.

TABLE IV
PHASE II - RESULT SUMMARY

MEASURE	VIBRATION CONDITIONS			F-RATIO	SIGNIFICANCE LEVEL
	0 Hz	2 Hz	4 Hz		
<u>Tracking Error</u>					
2.5-hour totals	85.77	88.74	85.91	.29	N. S.
4-hour totals	83.43	80.45	78.65	1.00	N. S.
8-hour totals	76.35	80.48	78.56	.47	N. S.
<u>Attentional Selectivity</u>					
<u>Total Reaction Time</u>					
2.5-hour means	4.30	4.16	4.00	2.73	N. S.
4-hour means	4.20	3.93	4.08	.94	N. S.
8-hour means	4.04	4.04	3.86	2.16	N. S.
<u>Wilkinson Vigilance</u>					
<u>% Correct</u>					
2.5-hour means	41	56	43	5.45	p < .025
4-hour means	45	50	50	1.00	N. S.
8-hour means	52	54	52	.14	N. S.
<u>Visual Acuity % Correct</u>					
2.5-hour means	68	70	72	.35	N. S.
4-hour means	72	72	74	.33	N. S.
8-hour means	76	77	80	.79	N. S.
<u>Task Difficulty Rating</u>					
2.5-hour means	4.0	4.3	5.45	4.95	p < .05
4-hour means	4.14	4.28	4.48	3.71	N. S.
8-hour means	3.89	4.20	4.12	.46	N. S.
<u>Motion Severity Rating</u>					
2.5-hour means	1.52	3.78	4.75	20.68	p < .001
4-hour means	1.73	4.03	4.36	12.11	p < .001
8-hour means	1.99	3.83	3.93	8.35	p < .005
<u>Kinesthetic-Finger*</u>					
2.5-hour means	.37	-.16	-.21	3.68	N. S.
4-hour means	-.04	.04	-.17	.44	N. S.
8-hour means	-.15	-.23	-.08	.21	N. S.
<u>Manual Dexterity*</u>					
<u>Number of Pins</u>					
2.5-hour means	-1.25	-3.62	+.12	1.98	N. S.
4-hour means	.38	.25	1.25	.07	N. S.
8-hour means	-.50	1.25	.88	.36	N. S.
<u>Flicker Fusion Flash Rate*</u>					
2.5-hour means	-5.52	-1.99	-2.61	1.30	N. S.
4-hour means	-.02	-1.25	-2.89	.92	N. S.
8-hour means	-3.32	-.99	-3.71	3.38	N. S.
<u>Vasomotor Reaction Time*</u>					
2.5-hour means	.31	.31	.15	1.04	N. S.
4-hour means	.36	.29	.38	.30	N. S.
8-hour means	.12	-.09	.07	1.93	N. S.
<u>Heart Rate (Last minute)</u>					
2.5-hour means	76.42	75.32	79.48	2.67	N. S.
4-hour means	76.28	75.86	77.20	.21	N. S.
8-hour means	78.50	78.20	79.80	.66	N. S.
<u>Dynamometer*</u>					
<u>(right hand)</u>					
2.5-hour means	1.42	-.31	1.58	.75	N. S.
4-hour means	-1.26	1.61	3.20	1.35	N. S.
8-hour means	2.34	2.09	0.28	.38	N. S.

*Post-test minus pretest difference scores.

The psychophysiological test difference scores showed only what appear to be incidental significances when compared between conditions. Some trends, unrelated to the vibration conditions did occur. For example, during 2.5 hour testing sessions, 11 of the 12 kinesthetic difference scores were negative, indicating that subjects tended to show less sensitivity following all experimental runs. This trend is less prominent during the 4- and 8-hour runs and may be entirely due to chance. Post-test flicker fusion rates were significantly slower than pretest rates ($t = 2.99$ - 2.5 hour / 1.67 - 4 hour / 4.01 - 8 hour, $p < .05$), however, none of the vibration conditions produced a significantly greater difference. This result is consistent with Phase I results.

The remaining tests showed little of interest and produced only what appears to be incidental results, except for the urinalysis and accelerometer data during 8-hour runs. The overall analysis on the urine data showed a significant difference between specific gravity measures. Specific gravity declined significantly following the first pretest sample, and thereafter, there appears to be a consistent significant decrease in the specific gravity during dynamic runs. Accelerometer data were statistically nonsignificant, indicating essential stability of seat-head vibration transmissibility throughout the runs.

2.3 PHASE III - MID-FREQUENCY SHORT-TERM EXPERIMENTS

2.3.1 Methods

2.3.1.1 Subjects and Training

A fresh panel of eight male University students with a median age of 24 was selected for Phase III experiments. One of the subjects had been used during Phase II experimentation. The procedure for selection, qualification, and training of this new panel was identical with that followed in previous phases.

2.3.1.2 Test Facility

The C-5 electrodynamic vibration machine, located in Building 824, Wright-Patterson Air Force Base, was used to produce the 8 and 16 Hz vertical (a_z) sinusoidal vibration used during this phase of experimentation. The C-5 vibration driving head stands approximately 90 cms from ground level. A new platform and enclosure was built around the C-5. Metal steps placed on either side of the C-5, which were bolted to the plywood floor, allowed subjects to board the vibration platform. (See Figure 3)

The enclosure consisted of similar masonite panels, arranged in an identical manner to those used during Phases I and II experiments. As was our intention, the completed C-5 set-up was spatially identical with the Western Gear set-up. Visual acuity was again measured utilizing a mirror mounted approximately 2.4 m in front of the subject reflecting Landolt cards mounted 3.7 m behind the subject, which again provided the necessary 6.1 m viewing distance.

Due to force limitations, the C-5 vibrator was not capable of supporting the weight of both the subject and the vibration seat. Thus, it was necessary to construct a support system whereby the driven mass was suspended on four air bags so that, with each subject aboard the C-5 the armature was maintained in its proper equilibrium position for excitation. The supporting structure, which included the metal steps, did not interfere in any way with the subject during experimentation. (See Figure 4)



Figure 3. C-5 Experimental Testing Facility (Photo).

2.3.1.3 Experimental Testing Apparatus

The experimental testing apparatus used in Phase III was the same as that used in Phase I, previously described.

2.3.1.4 Procedure

As with the apparatus, the procedure used during Phase III short-term runs was identical with that used during Phase I.

2.3.1.5 Experimental Design

The same statistical tests were performed on Phase III data as were used in the previous analyses.

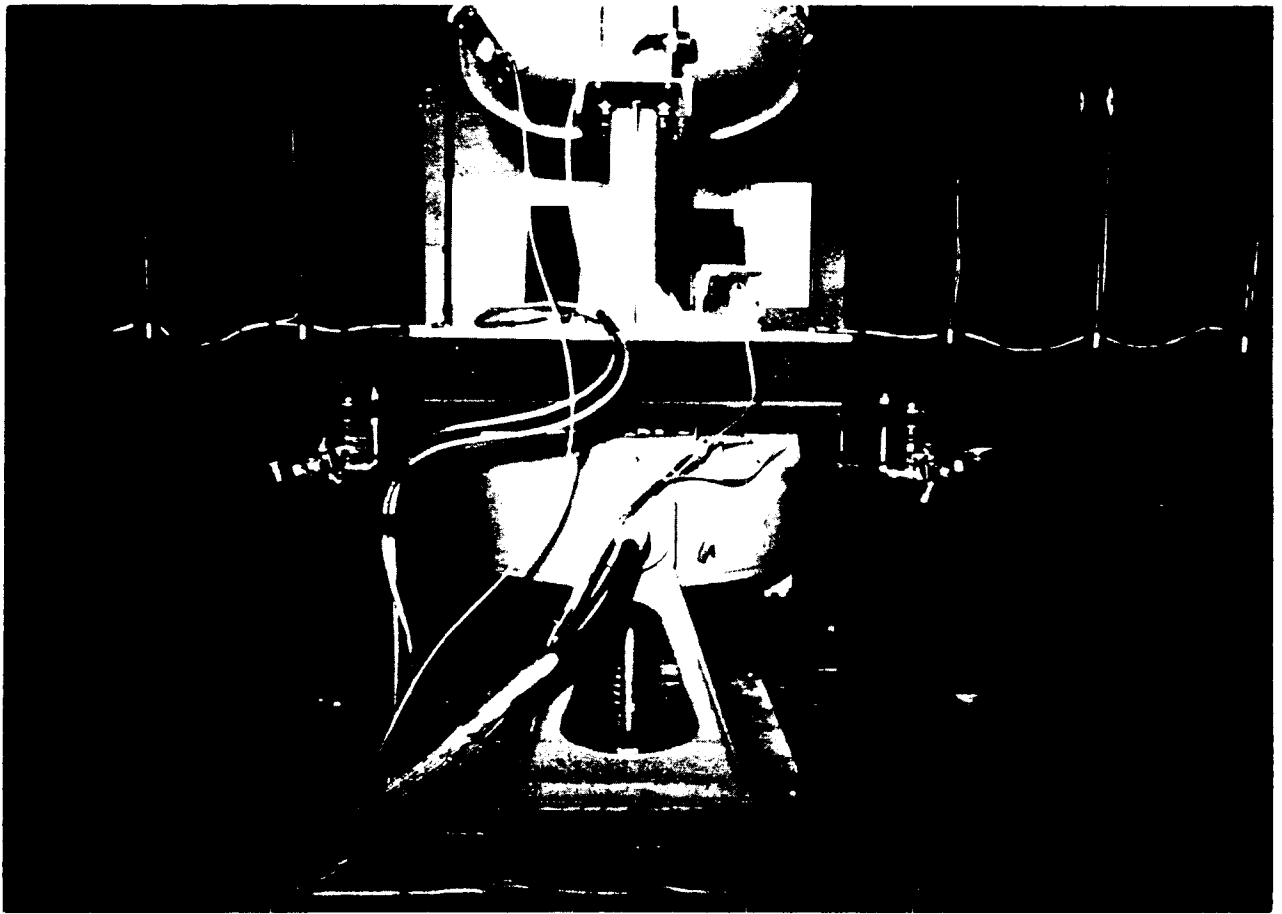


Figure 4. C-5 Air Suspension (Photo).

2.3.2 Results

A complete list of Phase III results are tabulated in Appendix B. Overall Phase III results appear in Table VI. As can be seen, the results did not show any consistent significant differences between vibration conditions with the continued exception of the subjective ratings. Total tracking scores during 16-minute exposures appeared numerically highest during 8 Hz exposures but this trend did not continue during the 25-minute runs which produced virtually identical means and no significant differences between conditions. The TD rating analysis showed significant results with 8 and 16 Hz ratings appearing higher than 0 Hz ratings during 16-minute runs and 16 Hz ratings

TABLE V
 PHASE III - VIBRATION CONDITIONS
 (Short Duration, Mid-Frequency Runs)

Frequency	Exposure Time (minutes)	Fatigue-decreased Proficiency Boundary (ISO)*
0	16	(---)
8	16	0.216
16	16	0.433
0	25	(---)
8	25	0.184
16	25	0.362

Note: Appendix E, Series I Short Duration Experiments, Exhibit B shows a typical running protocol for pre- and post-vibration testing. Exhibit C gives a schematic chart showing the timing of performance and subjective tests during vibration and control periods.

*ISO 2631-1974, values listed are "peak g" (z-axis) accelerations at the seat.

TABLE VI
PHASE III - RESULT SUMMARY

MEASURE	VIBRATION CONDITIONS			F- RATIO	SIGNIFICANCE LEVEL
	0 Hz	8 Hz	16 Hz		
<u>Tracking Error</u>					
16-minute total	94.45	108.32	100.45	3.80	.05
25-minute total	81.70	80.02	81.76	.14	N. S.
<u>Attentional Selectivity</u>					
<u>Total Reaction Time</u>					
16-minute total	2.44	2.42	2.38	.28	N. S.
25-minute total	3.77	3.83	3.81	.34	N. S.
<u>Visual Acuity % Correct</u>					
16-minute means	78	73	64	3.78	.05
25-minute means	76	75	69	1.32	N. S.
<u>Task Difficulty Rating</u>					
16-minute means	3.38	5.62	5.25	6.76	.01
25-minute means	4.12	4.38	5.62	3.99	.05
<u>Motion Severity Rating</u>					
16-minute means	1.25	5.25	6.50	49.54	.001
25-minute means	1.75	4.88	6.12	22.44	.001
<u>Kinesthetic-Finger*</u>					
16-minute means	- .29	- .08	- .13	.72	N. S.
25-minute means	- .00	+ .04	- .06	.22	N. S.
<u>Manual Dexterity*</u>					
<u>Number of Pins</u>					
16-minute means	- .37	.50	- 1.75	.36	N. S.
25-minute means	+2.38	1.50	1.75	.13	N. S.
<u>Flicker Fusion Flash Rate*</u>					
16-minute means	- .81	- .43	- 1.76	.31	N. S.
25-minute means	- .02	- 1.75	- .82	1.17	N. S.
<u>Vasomotor Reaction Time*</u>					
16-minute means	- .06	- .03	- .01	.45	N. S.
25-minute means	- .01	- .02	.02	.24	N. S.
<u>Heart Rate (last minute)</u>					
16-minute means	76.0	82.5	82.0	1.48	N. S.
25-minute means	78.7	78.4	81.3	.60	N. S.
<u>Dynamometer*</u>					
16-minute means	1.36	.71	- .14	.30	N. S.
25-minute means	.06	1.16	.85	.06	N. S.

*Post-test minus pretest difference scores.

higher than 0 and 8 Hz ratings during the 25-minute runs. Motion severity ratings continued to show highly significant results with both 8 and 16 Hz ratings much higher than the control ratings during both 16- and 25-minute runs. The Hockey test results were not significant and inspection of the total between vibration conditions reveals no trend.

Visual acuity was significantly degraded at 16 Hz during 16-minute runs. However a similar trend appearing in the data during 25-minute runs but was not confirmed upon statistical analysis.

Heart rate was not significantly different between conditions although the mean scores were higher during both dynamic runs than static runs. The physiological tests showed nothing save for the continued significant change ($t = 1.90$, $p < .05$) between all pre-test flicker fusion versus post-fusion scores. Urinalysis again revealed no significant results.

The accelerometer data were highly significant at 8 Hz during 16-minute runs, showing a steady, unexplained rise in transmissibility with each sampling through the run and no significant results were obtained for 25-minute runs.

TABLE VII
 PHASE IV - VIBRATION CONDITIONS
 (Long Duration, Mid-Frequency Runs)

Frequencies	Exposure Time (hours)	Fatigue-decreased Proficiency Boundary (ISO)*
0	2.5	(---)
8	2.5	0.012
16	2.5	0.203
0	4.0	(---)
8	4.0	0.076
16	4.0	0.153
0	8.0	(---)
8	8.0	0.045
16	8.0	0.091

Note: Appendix E, Series 2 Long Duration Experiment, Exhibit B shows a typical running protocol for pre- and post-vibration testing. Exhibit C gives a schematic chart showing the activities during each 30-minute block.

* ISO 2631-1974, values are listed in peak "g" (z-axis) at the seat.

2.4 PHASE IV - MID-FREQUENCY LONG-TERM EXPOSURES

2.4.1 Methods

2.4.1.1 Subjects and Training

Phase IV subject selection procedures were similar to previous phases with eight male University students having a median age of 24 comprising the experimental panel.

2.4.1.2 Test Facility

Phase IV used the same test facility as was used in Phase III.

2.4.1.3 Experimental Testing Apparatus

Phase IV used the same apparatus as was used in Phase II.

2.4.1.4 Procedure

Phase IV used the same testing procedure as was used in Phase II.

2.4.1.5 Experimental Design

The same statistical designs were utilized in analyzing Phase IV data as were used in Phase II.

2.4.2 Results

A complete list of Phase IV results appears in Appendix B. Overall results are listed in Table VIII. Again, except for the subjective ratings, the experimental conditions did not produce any significant results. Total tracking error scores were virtually identical between conditions and in some cases were slightly lower during dynamic runs.

TABLE VIII
PHASE IV - RESULT SUMMARY

MEASURE	VIBRATION CONDITIONS			F- RATIO	SIGNIFICANCE LEVEL
	0 Hz	3 Hz	16 Hz		
<u>Tracking Error</u>					
2.5-hour totals	67.60	66.11	69.75	.50	N. S.
4-hour totals	72.52	70.62	69.01	2.59	N. S.
8-hour totals	78.09	78.64	77.49	.06	N. S.
<u>Attentional Selectivity</u>					
<u>Total Reaction Time</u>					
2.5-hour means	3.91	3.81	3.90	.57	N. S.
4-hour means	4.08	3.94	3.91	1.14	N. S.
8-hour means	4.13	4.31	4.11	.98	N. S.
<u>Wilkinson Vigilance</u>					
<u>% Correct</u>					
2.5-hour means	65	71	65	.55	N. S.
4-hour means	55	62	58	2.20	N. S.
8-hour means	56	53	49	1.82	N. S.
<u>Visual Acuity % Correct</u>					
2.5-hour means	74	73	77	.20	N. S.
4-hour means	71	77	74	2.34	N. S.
8-hour means	85	79	84	1.13	N. S.
<u>Task Difficulty Rating</u>					
2.5-hour means	3.52	4.62	5.00	10.49	.005
4-hour means	3.72	4.45	4.58	5.48	.025
8-hour means	4.14	4.08	4.53	1.97	
<u>Motion Severity Rating</u>					
2.5 hour means	2.08	5.08	5.78	25.31	.001
4-hour means	1.88	4.91	5.22	20.03	.001
8-hour means	2.00	4.56	5.10	14.09	.001
<u>Kinesthetic-Finger*</u>					
2.5-hour means	- .14	- .10	- .36	.72	N. S.
4-hour means	- .04	- .22	- .23	.76	N. S.
8-hour means	.14	- .02	- .23	2.58	N. S.
<u>Manual Dexterity*</u>					
<u>Number of Pins</u>					
2.5-hour means	- .62	2.00	- .50	.85	N. S.
4-hour means	.50	- .88	- .88	.29	N. S.
8-hour means	- .87	.12	2.88	1.37	N. S.
<u>Flicker Fusion Flash Rate*</u>					
2.5-hour means	-1.96	-2.39	-1.55	1.13	N. S.
4-hour means	- .69	-1.41	-1.48	.22	N. S.
8-hour means	-1.51	-2.19	-3.48	2.28	N. S.
<u>Vasomotor Reaction Time*</u>					
2.5-hour means	.06	- .04	.14	3.33	N. S.
4-hour means	- .05	+ .06	- .16	1.62	N. S.
8-hour means	- .02	- .02	- .02	.11	N. S.
<u>Heart Rate (last minute)</u>					
2.5-hour means	83.2	86.4	85.2	.80	N. S.
4-hour means	82.4	85.9	86.7	1.60	N. S.
8-hour means	69.9	79.8	76.2	2.05	N. S.
<u>Dynamometer*</u>					
2.5-hour means	.56	.91	- .76	.47	N. S.
4-hour means	- .73	- .31	- .26	.05	N. S.
8-hour means	2.28	.64	1.91	.44	N. S.

*Post-test minus pretest difference scores.

Visual acuity, Wilkinson vigilance and the Hockey tasks yielded nonsignificant results; however, the tendency for Hockey reaction times to be shorter during dynamic runs continued.

TD ratings were significantly higher during dynamic runs for 2.5- and 4-hour exposures, but not for 8-hour ratings. MS ratings were again highly significant during all three exposure durations with highest ratings occurring in conjunction with the dynamic runs.

Again, the pre- and post-test batteries revealed nothing of significance between conditions, with flicker fusion rates continuing to be equally reduced by all vibration conditions. This overall reduction was again significant ($t = 5.3 - 2.5 \text{ hour} / 12.45 - 4 \text{ hour} / 4.56 - 8 \text{ hour}, p < .05$).

The urinalysis and accelerometer data again revealed no significant results. Heart rates were not significantly different between conditions but did appear numerically to be consistently higher during dynamic runs as opposed to control.

SECTION 3

DISCUSSION

- Subjective ratings. The significant differences which emerged in the subjective ratings of motion severity and task difficulty showed that subjects attributed a moderate degree of severity to the vibration and also rated the tracking and secondary tasks more difficult during vibration than during control runs. However, the differences in subjective ratings were not reflected in performance decrements. Thus, although subjects tended to rate the motion more severe and the tasks more difficult during vibration, their actual performance was not significantly affected.

- Tracking. Compensatory tracking, the most widely used indicator of vibration induced performance decrements, was not found to be significantly degraded by whole-body vertical vibration at the current ISO FDP Boundary during exposures up to 8 hours (up to 16 Hz). The virtual identity of the tracking means obtained during the long-term runs, and the fact the tracking error scores were in some instances marginally smaller during vibration suggests that the current ISO FDP limits may be overly conservative.

The long-term tracking error showed a general tendency to decrease during the first block, possibly due to a warm-up or continued practice effect, and then to increase steadily across blocks until the final block, during which a recovery effect was noted. In spite of the monotony of the tasks, subjects remained attentive and variations in tracking error between blocks was relatively small. Apparently the timing of performance and rest breaks provided sufficient rest to avoid inattentive performance or any other condition (such as leg cramps). Given these results, it appears extremely likely that the acceleration levels of the ISO FDP Boundary for 2.5 - 8 hour exposures could have been exceeded in our study without causing measurable tracking decrements.

- Attentional selectivity. The results of the Hockey test of attentional selectivity showed that subject's ability to detect transient visual stimuli was in no way degraded by the FDP acceleration levels. Moreover, the results in no way indicate that subjects were being stressed by either short or long term runs because there was no tendency in the data for subject's peripheral attention to be degraded or altered spatially, a phenomenon which Hockey (1970) had observed using noise as a stressor. The general tendency towards numerically longer reaction times as the experimental duration increased was likely caused by an increase in fatigue or decline in arousal level which occurred uniformly during both control and vibration conditons.

Inspection of the data also revealed that, although an insignificant finding, there appeared to be a consistent tendency for subjects to detect signals quicker during vibration than during control runs which is a finding consistent with the proposition that the FDP levels were serving to enhance performance by arousing subjects, an effect opposite from that supposedly precluded by the ISO standard. These results indicate that it is unlikely that vibration levels somewhat in excess of the current FDP boundary would have caused significant decrements in either visual detection reaction times or peripheral attention.

- Wilkinson auditory vigilance. The Wilkinson auditory vigilance task results demonstrated that no decrease in auditory vigilance occurred due to vibration stress at the levels used, up to 8 hours. The total lack of trends again suggests that our subjects could possibly have received vibration in excess of the FDP level without reducing auditory vigilance.

- Visual acuity. The results of the visual acuity data corresponding to the presentation of 12 clock positions was similar to the data in which only positions 3, 6, 9, and 12 were scored. This result confirmed our expectation that the modification of Landolt's original task to include all 12 clock positions would not affect the data. Because the visual material was stationary and at a distance of 6.1 meters, we expected from previous data in the literature

(Guignard, 1972) that visual acuity decrements would be most likely to occur at 16 Hz. The fact that visual acuity was only significantly degraded at the highest 16 Hz acceleration level (16-minute exposure level) indicates that vibration at the FDP limit for exposure durations in excess of 16 minutes would not be likely to interfere directly with visual resolution acuity. Because visual acuity is well documented as being sensitive to vibration, the lack of significant findings at the FDP levels again suggests that the standard may be too conservative, at least for long term exposures when task performance is the criterion of conservation.

- Pre- and post-test physiological measures. The lack of findings in relation to the dynamometer, manual dexterity, kinesthetic and vasomotor tests clearly indicates that whole-body vibration at the FDP levels used did not result in any peripheral detectable neurovascular or sensorimotor effects. Flicker fusion proved to be a sensitive test with significant overall pre-/post-test results occurring after all durations of exposure; however, this test did not show significantly more fatigue following vibration runs than during control runs. The fact that flicker fusion rates were significantly reduced following the performance of the tracking and secondary tasks is consistent with the interpretation that, although subjects were being fatigued by the tasks, vibration was having no additive effect. Heart rate, although not found to be significantly different between conditions, did show a consistent tendency to be higher during vibration than control runs as a whole, which is consistent with previous indications that vibration may have been a mildly arousing factor.

- Urine constituents. These tests consistently indicated that no stress related changes in the urine of our subjects occurred as a result of whole-body vibration. Hence, it can be stated that the levels of stimulation used (ISO FDP Boundary) did not produce even a hint of renal or urinary tract damage.

- Accelerometer data. It was not possible to correlate seat-head acceleration transmissibility with performance because of the absence of any consistent reduction in performance due to vibration. As intended, however, the data confirmed that subjects did maintain a stable sitting posture during vibration.

SECTION 4

CONCLUSIONS

These findings suggest that the current ISO FDP boundary is overly protective and may accordingly be unnecessarily restrictive of human work function if applied in industry, particularly for the longer durations of exposure typical of the working day. Another possible interpretation of the data is that all of our wide variety of performance tests were insensitive measures of human vibration tolerance, which is unlikely for the following reasons:

1. The wide variety of tests used - fourteen tests of central or peripheral performance and physiological state were performed ranging in sensitivity from a measure of grip strength to critical flicker fusion frequencies. Both tracking skill and visual acuity, which are both well documented as being sensitive measures of vibration induced performance decrements, were not found to be affected by z-axis whole-body vibration at the current FDP levels in the most critical range of 2 to 16 Hz.

2. Task demands - subjects were required to simultaneously perform tracking and a secondary task thus dividing their attention. It is unlikely that such task demands were insufficient to detect stressful vibration interference.

3. Training - a total of four hours of training on the tracking task had been required before the subjects' error scores became reasonably asymptotic. This suggests that the tracking task was fairly demanding and, accordingly, likely to have been sensitive to an induced environmental stress superimposed on the task load.

4. Task difficulty ratings - the overall mean TD rating was 4.3, which corresponds to a verbal response of "not very easy" which indicates that subjects did not rate their performance tasks as a group as being easy, which lends further support to the foregoing argument.

SECTION 5

SUMMARY

The international standard (ISO-2631-1974) guidelines for human exposure to whole-body vertical vibration were investigated using groups of eight male volunteer subjects who were required to undergo a battery of performance, physiological and subjective tests during sinusoidal vibration and control (no vibration) conditions while seated in a vehicle-driving posture. The exposure durations included 16 and 25 minutes; 2.5, 4 and 8 hours and the vibration frequencies were 2, 4, 8 and 16 Hz presented at acceleration levels corresponding to the ISO "Fatigue-decreased Proficiency (FDP) Boundary". The results obtained during vibration were compared with data from control runs of identical duration and protocol, using a standard computational ANOVA procedure. The performance tests included tracking, attentional selectivity, auditory vigilance and visual acuity. The physiological observations included heart rate and pre- and post-exposure analysis of urine constituents, hand vasomotor reaction time, grip strength, manual dexterity, critical flicker fusion frequency and hand and palm kinesthetic sensitivity. Subjective ratings of task difficulty and motion severity were taken. The stability of seat-head vibration transmission during runs was also measured during vibration runs using an upper jaw mounted accelerometer.

Vibration at the ISO "FDP" levels was found to have a negligible effect on the performance or physiological state of subjects when compared with the control runs. Significant differences did, however, emerge between the subjective ratings. Subjective ratings of motion severity and task difficulty were both significantly higher during vibration runs than during control runs; however, the subjective assessments of vibration stress were not reflected in the performance results which showed no substantial differences or trends. The fact that there were no significant differences or trends in any of the performance or physiological data strongly indicates that the current ISO "FDP" Boundary may be too conservative.

REFERENCES

- A'Harrah, R. C. "Low Altitude, High-speed Handling and Riding Qualities." Paris: NATO AGARD. AGARD Report 443, 1963.
- Chaney, R. E. and Parks, D. L. "Visual-Motor Performance During Whole-Body Vibration." Wichita, Kansas: Boeing Co., Technical Report D3-3512-5, 1964.
- Grether, W. F. "Vibration and Human Performance." USAF Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, Technical Report 70-10, 1970.
- Guignard, J. C. Vibration In: "Aeromedical Aspects of Vibration and Noise", by Guignard, J. C. and King, P. F., Paris: NATO/AGARD. AGARDograph AG-151. Part One. 1972.
- Guignard, J. C. and Irving, A. "Effects of Low Frequency Vibration on Man." Engineering (London), 190, 364-367, 1960.
- Harris, C. S., Chiles, W. D., and Touchstone, R. M. "Human Performance as a Function of Intensity of Vibration at 5 cps." USAF Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, Technical Report 64-83, 1964.
- Hockey, G. R. J. "The Effect of Loud Noise on Attentional Selectivity." Quart. J. Exp. Psychol., 22, 28-36, 1970.
- Holland, C. L. "Performance Effects of Long Term Random Vertical Vibration." Human Factors, 9, 93-104, 1970.
- International Organization for Standardization. Guide for the Evaluation of Human Exposure to Whole-Body Vibration. Geneva: ISO. International Standard ISO 2631-1974.
- Landolt, E. Tableau d'optotypes pour la determination de l'acuite visuelle. Soc. Francais D'ophthal., 1889.
- Shoenberger, R. W. "Human Performance as a Function of Direction and Frequency of Whole-Body Vibration." USAF Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, Technical Report 70-7, 1970.
- Shoenberger, R. W. "Human Response to Whole-Body Vibration." Perceptual and Motor Skills, 34, 127-160, 1972.

Weisz, A. Z., Goddard, C., and Allen, R. W. "Human Performance Under Random and Sinusoidal Vibration." USAF Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, Technical Report 65-209, 1965.

Wilkinson, R. T. "Methods for Research on Sleep Deprivation and Sleep Function." Int. Psychiat. Clin., 7, 369-382, 1970.

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APPENDIX A
DATA TABLES FROM LOW-FREQUENCY EXPERIMENTS
(WESTERN GEAR)

TABLE I
MEAN VALUES FOR TOTAL TRACKING ERROR

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	3 Hz		
16 Minute Total	101.76	112.68	115.65	102.41	1.95	N. S.
25 Minute Total	76.92	83.62	83.68	75.39	1.21	N. S.
2.5 Hour Total	85.77	88.74	85.91	-	.29	N. S.
Block 1	85.94	88.80	83.61	-	.51	"
" 2	90.42	92.26	86.45	-	.72	"
" 3	86.25	88.65	88.00	-	.10	"
" 4	83.01	87.89	87.72	-	1.53	"
" 5	83.20	84.29	83.02	-	.05	"
4.0 Hour Total	83.43	90.45	78.65	-	1.00	N. S.
Block 1	83.06	79.00	87.67	-	.39	"
" 2	85.16	79.20	81.39	-	.97	"
" 3	79.62	81.99	75.71	-	1.56	"
" 4	88.16	78.42	72.22	-	2.28	"
" 5	77.95	88.04	76.14	-	2.00	"
" 6	80.96	79.34	77.64	-	.11	"
" 7	93.87	81.51	77.52	-	5.33	P < .025
" 8	79.56	76.15	80.91	-	.75	N. S.
8.0 Hour Total	76.85	80.48	78.56	-	.47	N. S.
Block 1	72.71	80.41	77.49	-	.65	"
" 2	72.19	73.32	69.94	-	.18	"
" 3	74.79	74.39	70.32	-	.62	"
" 4	70.24	68.37	72.59	-	.62	"
" 5	71.14	72.61	75.40	-	.38	"
" 6	71.72	75.15	72.96	-	.24	"
" 7	73.41	81.07	75.94	-	.72	"
" 8	78.54	73.48	77.39	-	4.45	P < .05
" 9	76.70	82.39	82.31	-	1.16	N. S.
" 10	83.06	87.04	83.99	-	.29	"
" 11	82.67	94.71	87.07	-	1.38	"
" 12	90.69	87.46	82.12	-	.53	"
" 13	79.55	86.21	91.24	-	.46	"
" 14	74.10	80.90	82.24	-	1.18	"
" 15	83.59	88.75	86.01	-	.20	"
" 16	74.61	81.35	79.95	-	.99	"

TABLE 2
MEAN VALUES FOR REACTION TIME ON ATTENTIONAL SELECTIVITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Total	2.49	2.46	2.45	2.37	1.65	N. S.
20° Light Totals	2.36	2.31	2.25	2.19	4.41	P .
35° " "	2.44	2.38	2.39	2.33	.31	N. S.
50° " "	2.54	2.52	2.69	2.38	1.46	N. S.
65° " "	2.45	2.43	2.39	2.34	.68	N. S.
80° " "	2.68	2.67	2.56	2.61	.27	N. S.
25 Minute Totals	4.13	3.98	4.10	4.10	.63	N. S.
20° Light Totals	3.99	3.76	3.92	3.82	.47	N. S.
35° " "	4.02	3.81	4.17	4.08	.72	N. S.
50° " "	4.12	4.03	4.02	4.06	.13	N. S.
65° " "	4.11	3.97	4.15	3.96	.29	N. S.
80° " "	4.41	4.33	4.26	4.59	.28	N. S.
2.5 Hour Totals	4.30	4.16	4.00	-	2.73	N. S.
20° Light Totals	3.95	3.87	3.78	-	1.47	N. S.
35° " "	4.07	3.98	3.81	-	1.85	N. S.
50° " "	4.52	4.40	4.05	-	3.08	N. S.
65° " "	4.36	4.26	4.14	-	.91	N. S.
80° " "	4.64	4.30	4.24	-	1.92	N. S.
Block 1 Total Reaction Time	4.32	4.14	4.04	-	1.85	N. S.
20° Light	4.13	3.78	3.76	-	5.09	.025
35° " "	4.12	4.03	3.87	-	1.27	N. S.
50° " "	4.49	4.44	4.04	-	1.21	N. S.
65° " "	4.30	4.20	4.33	-	.10	N. S.
80° " "	4.57	4.27	4.22	-	3.87	.05
Block 3 Total Reaction Time	4.44	4.35	4.10	-	.87	N. S.
20° Light	3.86	4.00	3.86	-	.25	N. S.
35° " "	4.23	4.15	3.93	-	.80	N. S.
50° " "	4.52	4.55	4.24	-	.54	N. S.
65° " "	4.45	4.53	4.20	-	.58	N. S.
80° " "	5.16	4.54	4.30	-	1.37	N. S.
Block 5 Total Reaction Time	4.15	3.99	3.86	-	4.32	N. S.
20° Light	3.87	3.82	3.70	-	.67	N. S.
35° " "	3.86	3.78	3.63	-	1.51	N. S.
50° " "	4.54	4.21	3.88	-	3.31	N. S.
65° " "	4.32	4.06	3.90	-	6.62	N. S.
80° " "	4.18	4.08	4.20	-	.29	N. S.
4.0 Hour Total	4.20	3.93	4.08	-	.94	N. S.
20° Light Totals	3.93	3.69	3.85	-	.89	N. S.
35° " "	4.06	3.90	3.97	-	.27	N. S.
50° " "	4.34	3.93	4.14	-	1.16	N. S.
65° " "	4.27	4.00	4.10	-	1.08	N. S.
80° " "	4.38	4.14	4.34	-	.80	N. S.
Block 2 Totals	4.58	3.96	3.97	-	1.43	N. S.
20° Light	4.41	3.70	3.72	-	1.08	N. S.
35° " "	4.18	3.78	3.87	-	1.23	N. S.
50° " "	5.15	3.92	4.19	-	1.67	N. S.
65° " "	4.21	4.03	4.00	-	.28	N. S.
80° " "	4.92	4.38	4.06	-	1.56	N. S.

TABLE 2 (Continued)

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
Block 4 Totals	4.20	3.89	3.85	-	1.40	N.S.
20° Lights	3.71	3.70	3.64	-	.11	"
35° "	4.44	3.94	3.77	-	1.75	"
50° "	4.06	3.90	3.96	-	.96	"
65° "	4.42	3.93	3.93	-	1.39	"
80° "	4.38	3.98	3.95	-	1.17	"
Block 6 Totals	3.98	3.96	4.35	-	.92	N.S.
20° Lights	3.80	3.61	4.10	-	.88	"
35° "	3.81	4.10	4.16	-	1.00	"
50° "	4.08	3.89	4.22	-	1.96	"
65° "	4.12	4.08	4.44	-	.49	"
80° "	4.12	4.12	4.81	-	.78	"
Block 8 Totals	4.03	3.92	4.15	-	.27	N.S.
20° Lights	3.82	3.92	4.15	-	.25	"
35° "	3.81	3.81	4.08	-	.43	"
50° "	4.07	4.02	4.20	-	.15	"
65° "	4.33	3.95	4.03	-	.55	"
80° "	4.10	4.06	4.52	-	.64	"
8 Hour Totals	4.04	4.04	3.86	-	2.16	N.S.
20° Lights	3.79	3.81	3.67	-	.65	"
35° "	3.89	3.91	3.77	-	.95	"
50° "	4.16	4.07	3.93	-	2.35	"
65° "	4.12	4.14	3.90	-	1.69	"
80° "	4.25	4.27	4.01	-	1.95	"
Block 2 Totals	3.92	3.90	3.63	-	3.22	N.S.
20° Lights	3.69	3.63	3.45	-	1.56	"
35° "	3.66	3.67	3.55	-	.51	"
50° "	4.02	4.25	3.70	-	2.00	"
65° "	4.06	4.04	3.73	-	2.03	"
80° "	4.13	3.94	3.70	-	1.96	"
Block 4 Totals	3.89	3.79	3.74	-	.60	N.S.
20° Lights	3.70	3.52	3.50	-	2.07	"
35° "	3.79	3.70	3.75	-	.20	"
50° "	4.05	3.83	3.75	-	.86	"
65° "	3.89	3.89	3.84	-	.08	"
80° "	4.03	3.99	3.86	-	.34	"
Block 6 Totals	4.00	3.89	3.83	-	.71	N.S.
20° Lights	3.82	3.88	3.64	-	.62	"
35° "	4.03	3.86	3.76	-	.78	"
50° "	4.06	3.85	3.88	-	1.78	"
65° "	3.95	3.98	3.94	-	.02	"
80° "	4.11	3.90	3.94	-	1.08	"
Block 8 Totals	4.31	3.96	3.82	-	2.37	N.S.
20° Lights	3.98	3.76	3.64	-	3.89	.05
35° "	4.18	3.75	3.70	-	1.18	N.S.
50° "	4.31	4.00	4.04	-	.51	"
65° "	4.24	3.86	3.85	-	1.20	"
80° "	4.86	4.47	3.86	-	2.32	"
Block 10 Totals	4.42	4.56	4.17	-	1.20	N.S.
20° Lights	3.98	4.34	4.15	-	.25	"
35° "	4.04	4.20	3.92	-	.72	"
50° "	4.77	4.38	4.12	-	.80	"
65° "	4.84	5.10	4.19	-	1.26	"
80° "	4.49	4.76	4.47	-	.47	"

TABLE 2 (Continued)

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
Block 12 Totals	4.01	4.27	3.98	-	1.09	N.S.
20° Lights	3.75	3.99	3.77	-	.96	"
35° "	3.80	4.09	3.90	-	.54	"
50° "	4.26	4.30	4.04	-	.65	"
65° "	4.13	4.36	4.07	-	.41	"
80° "	4.11	4.62	4.14	-	1.35	"
Block 14 Totals	3.88	3.98	3.88	-	.26	N.S.
20° Lights	3.63	3.75	3.60	-	.53	"
35° "	3.74	4.06	3.75	-	.96	"
50° "	3.82	4.08	4.00	-	.91	"
65° "	3.98	3.84	3.94	-	.70	"
80° "	4.21	4.14	4.13	-	.06	"
Block 16 Totals	3.90	3.96	3.80	-	.97	N.S.
20° Lights	3.74	3.59	3.66	-	.95	"
35° "	3.86	3.97	3.83	-	.58	"
50° "	3.96	3.89	3.87	-	.32	"
65° "	3.84	4.05	3.66	-	2.20	"
80° "	4.08	4.32	4.00	-	1.13	"

TABLE 3
MEAN VALUES FOR AUDITORY VIGILANCE TASK

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
2.5 Hour Mean Totals						
Total #Yes Responses	6.62	8.81	7.25	-	3.76	.05
Block 2 #Yes	6.75	8.75	7.62	-	1.52	N.S.
Block 4 #Yes	6.50	8.88	6.88	-	5.70	.025
Total #Inventions	5.56	6.19	7.12	-	.55	N.S.
Block 2 #Invent.	5.38	7.50	7.38	-	.52	"
Block 4 #Invent.	5.75	4.88	6.88	-	1.90	"
Total % Correct	.41	.56	.43	-	5.45	.025
Block 2 %	.41	.56	.45	-	2.97	N.S.
Block 4 %	.40	.55	.41	-	4.16	.05
4.0 Hour Mean Totals						
Total #Yes Responses	7.50	8.03	8.25	-	.68	N.S.
Block 1	6.62	6.25	6.25	-	.09	"
Block 3	5.75	7.88	7.12	-	1.70	"
Block 5	8.75	9.00	10.38	-	1.43	"
Block 7	8.88	9.00	9.25	-	.07	"
Total #Inventions	5.31	4.31	4.97	-	.70	N.S.
Block 1	5.50	5.50	5.12	-	.08	"
Block 3	5.88	5.00	4.88	-	.27	"
Block 5	5.00	3.75	4.25	-	.94	"
Block 7	4.88	3.00	5.62	-	3.56	"
Total % Correct	.45	.50	.50	-	1.00	N.S.
Block 1	.40	.41	.40	-	.02	"
Block 3	.35	.51	.44	-	2.50	"
Block 5	.54	.55	.62	-	.73	"
Block 7	.51	.53	.56	-	.25	"
8.0 Hour Mean Totals						
Total #Yes Responses	8.61	8.89	8.50	-	.20	N.S.
Block 1	7.62	9.12	7.50	-	1.46	"
Block 3	8.00	8.75	8.00	-	.26	"
Block 5	7.88	8.00	8.12	-	.04	"
Block 7	9.12	8.88	9.00	-	.04	"
Block 9	9.75	11.25	8.75	-	1.90	"
Block11	9.50	8.25	9.25	-	.84	"
Block13	8.50	7.75	8.38	-	.18	"
Block15	8.50	9.12	9.00	-	.19	"
Total #Inventions	3.69	4.52	5.06	-	3.16	N.S.
Block 1	3.50	4.88	4.75	-	.81	"
" 3	3.50	4.12	6.25	-	2.40	"
" 5	4.25	3.12	5.00	-	1.36	"
" 7	4.38	5.75	5.62	-	.39	"
" 9	3.50	3.62	4.88	-	2.55	"
" 11	2.50	5.12	5.12	-	3.61	"
" 13	3.75	4.12	3.75	-	.07	"
" 15	4.12	5.38	5.12	-	.41	"
Total % Correct	.52	.54	.52	-	.14	N.S.
Block 1	.45	.55	.46	-	2.45	"
" 3	.48	.52	.49	-	.15	"
" 5	.50	.51	.52	-	.06	"
" 7	.57	.53	.56	-	.25	"
" 9	.61	.69	.53	-	2.05	"
" 11	.58	.51	.56	-	.92	"
" 13	.49	.45	.50	-	.22	"
" 15	.50	.52	.51	-	.09	"

TABLE 4
MEAN VALUES FOR TASK DIFFICULTY RATINGS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Total	3.50	4.75	4.37	4.25	1.25	N.S.
25 Minute Total	3.25	4.75	4.50	4.75	5.06	P .01
2.5 Hour Total	4.00	4.30	5.45	-	4.95	P .025
Block 1	3.38	4.00	5.00	-	4.72	P .05
" 2	4.12	4.62	6.12	-	3.87	P .05
" 3	3.50	4.00	5.38	-	6.23	P .025
" 4	4.88	4.62	5.88	-	2.57	N.S.
" 5	4.12	4.25	4.88	-	1.23	"
4.0 Hour Total	4.14	4.28	4.48	-	3.71	N.S.
Block 1	4.00	4.25	4.50	-	.51	"
" 2	3.75	3.25	3.88	-	.67	"
" 3	4.62	4.75	4.88	-	.08	"
" 4	4.12	4.12	4.38	-	.16	"
" 5	4.12	4.88	4.50	-	2.46	"
" 6	3.88	4.50	4.00	-	1.62	"
" 7	4.50	4.62	4.75	-	.15	"
" 8	4.12	3.88	5.00	-	2.29	"
8.0 Hour Total	3.89	4.20	4.12	-	.46	N.S.
Block 1	3.38	4.25	3.75	-	3.14	"
" 2	3.75	4.00	3.88	-	.27	"
" 3	4.25	4.00	3.88	-	.34	"
" 4	3.25	4.00	3.88	-	1.17	"
" 5	3.75	4.25	3.75	-	.70	"
" 6	3.75	3.75	3.88	-	.03	"
" 7	4.00	4.00	4.25	-	.14	"
" 8	3.00	3.75	4.00	-	1.94	"
" 9	3.50	4.00	4.37	-	1.45	"
" 10	3.75	4.00	4.12	-	.23	"
" 11	4.50	4.50	4.38	-	.10	"
" 12	4.12	4.62	4.25	-	.59	"
" 13	4.12	4.50	4.00	-	.51	"
" 14	4.00	4.25	4.38	-	1.00	"
" 15	4.88	4.50	4.88	-	.80	"
" 16	4.25	4.75	4.38	-	.92	"

TABLE 5
MEAN VALUES FOR VISUAL ACUITY COMPLETION TIMES

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
2.5 Hour Totals	54.18	53.85	52.40	-	.90	N.S.
Block 1	43.88	53.75	53.50	-	.01	"
" 2	54.12	55.50	52.50	-	1.68	"
" 3	54.38	53.88	51.50	-	1.05	"
" 4	54.12	52.62	52.12	-	.59	"
" 5	54.38	53.50	52.38	-	.29	"
4.0 Hour Totals	52.12	51.12	52.16	-	.45	N.S.
Block 1	52.75	52.00	52.12	-	.15	"
" 2	53.62	48.12	51.25	-	.23	"
" 3	53.50	52.00	52.88	-	.46	"
" 4	51.62	51.12	51.25	-	.86	"
" 5	53.12	51.25	51.75	-	.68	"
" 6	51.25	53.88	53.62	-	.03	"
" 7	49.75	50.75	52.12	-	1.31	"
" 8	51.38	49.88	52.25	-	.84	"
8.0 Hour Totals	51.19	51.66	50.57	-	.98	N.S.
Block 1	51.00	50.75	50.62	-	.03	"
" 2	51.88	48.25	49.75	-	1.85	"
" 3	51.50	48.75	48.25	-	.85	"
" 4	51.88	50.50	49.00	-	2.82	"
" 5	50.50	51.12	49.12	-	.48	"
" 6	50.12	53.38	47.50	-	3.65	"
" 7	50.38	52.62	50.38	-	2.59	"
" 8	44.75	50.62	49.38	-	.64	"
" 9	52.75	52.12	53.25	-	.15	"
" 10	50.50	53.00	51.00	-	.52	"
" 11	52.25	52.00	53.00	-	.39	"
" 12	49.88	51.50	50.38	-	.26	"
" 13	52.38	53.50	51.25	-	.77	"
" 14	53.75	53.25	51.25	-	.84	"
" 15	53.38	52.62	52.38	-	.21	"
" 16	51.88	52.50	52.62	-	.16	"

TABLE 6
MEAN VALUES FOR 12 POSITIONS # CORRECT/36 ON VISUAL ACUITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	64.20	62.15	62.16	69.37	.97	N.S.
25 Minute Totals	76.70	67.30	73.70	67.30	.76	N.S.
2.5 Hour Totals	.68	.70	.72	-	.35	N.S.
Block 1	.69	.72	.72	-	.15	"
" 2	.68	.68	.71	-	.11	"
" 3	.67	.68	.73	-	.64	"
" 4	.72	.74	.74	-	.07	"
" 5	.63	.68	.71	-	.65	"
4.0 Hour Totals	.72	.72	.74	-	.33	N.S.
Block 1	.75	.71	.79	-	3.62	"
" 2	.70	.65	.78	-	1.35	"
" 3	.65	.76	.71	-	1.58	"
" 4	.75	.74	.77	-	.25	"
" 5	.73	.78	.71	-	.63	"
" 6	.75	.71	.72	-	.29	"
" 7	.70	.67	.74	-	.70	"
" 8	.70	.73	.69	-	.92	"
8.0 Hour Totals	.76	.77	.80	-	.79	N.S.
Block 1	.69	.81	.77	-	1.91	"
" 2	.81	.75	.78	-	.84	"
" 3	.72	.82	.78	-	1.31	"
" 4	.77	.79	.78	-	.07	"
" 5	.78	.76	.82	-	.80	"
" 6	.75	.68	.78	-	2.05	"
" 7	.95	.78	.78	-	1.11	"
" 8	.69	.80	.83	-	2.54	"
" 9	.74	.78	.79	-	.52	"
" 10	.73	.73	.72	-	.01	"
" 11	.74	.77	.80	-	1.10	"
" 12	.81	.83	.80	-	.55	"
" 13	.71	.76	.86	-	3.96	"
" 14	.76	.76	.84	-	1.67	"
" 15	.73	.75	.83	-	2.76	"
" 16	.79	.79	.78	-	.08	"

TABLE 7
MEAN VALUES FOR 4 POSITION # CORRECT/12 ON VISUAL ACUITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
2.5 Hour Totals	.77	.79	.80	-	.11	N.S.
Block 1	.80	.82	.78	-	.14	"
" 2	.74	.75	.77	-	.04	"
" 3	.78	.81	.84	-	.50	"
" 4	.78	.80	.81	-	.09	"
" 5	.73	.79	.78	-	.28	"
4.0 Hour Totals	.80	.80	.82	-	.37	N.S.
Block 1	.73	.79	.83	-	2.40	"
" 2	.79	.74	.82	-	.36	"
" 3	.84	.81	.77	-	.71	"
" 4	.88	.90	.87	-	.18	"
" 5	.82	.83	.86	-	.21	"
" 6	.86	.77	.78	-	.71	"
" 7	.74	.73	.86	-	1.56	"
" 8	.78	.83	.76	-	.73	"
8.0 Hour Totals	.84	.84	.86	-	.30	N.S.
Block 1	.82	.92	.83	-	1.78	"
" 2	.86	.84	.89	-	.35	"
" 3	.78	.84	.82	-	.44	"
" 4	.86	.78	.79	-	.65	"
" 5	.91	.79	.88	-	2.16	"
" 6	.82	.72	.86	-	1.59	"
" 7	.84	.94	.79	-	.22	"
" 8	.78	.86	.88	-	2.60	"
" 9	.83	.84	.91	-	1.56	"
" 10	.82	.77	.79	-	.18	"
" 11	.86	.86	.88	-	.40	"
" 12	.91	.91	.86	-	.74	"
" 13	.81	.88	.89	-	.65	"
" 14	.86	.82	.92	-	1.00	"
" 15	.85	.81	.90	-	1.42	"
" 16	.91	.92	.84	-	1.31	"

TABLE 8
MEAN VALUES FOR MOTION SEVERITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	1.00	4.80	5.30	5.80	23.58	.010
25 Minute Totals	1.00	4.10	5.12	5.62	26.90	.010
2.5 Hour Totals	1.52	3.78	4.75	-	20.68	.001
Block 1	1.38	3.38	4.88	-	19.55	.001
" 2	1.75	3.88	4.88	-	15.92	.001
" 3	1.50	3.75	4.75	-	19.79	.001
" 4	1.38	4.00	4.75	-	15.69	.001
" 5	1.62	3.88	4.50	-	22.30	.001
4.0 Hour Totals	1.73	4.03	4.36	-	12.11	.001
Block 1	1.62	4.00	4.12	-	14.31	.001
" 2	1.75	3.62	4.25	-	11.91	.001
" 3	1.62	4.00	4.25	-	11.39	.005
" 4	1.88	4.12	4.38	-	11.54	.005
" 5	1.62	4.12	4.25	-	6.13	.025
" 6	1.75	4.12	4.50	-	9.79	.005
" 7	1.88	4.00	4.38	-	11.48	.005
" 8	1.75	4.25	4.75	-	13.16	.001
8.0 Hour Totals	1.99	3.83	3.93	-	8.35	.005
Block 1	1.50	3.75	3.75	-	11.57	.005
" 2	1.88	3.62	3.50	-	8.84	.005
" 3	2.12	3.88	3.75	-	5.69	.025
" 4	1.75	3.88	3.75	-	12.03	.001
" 5	1.88	3.88	3.75	-	8.48	.005
" 6	1.88	3.75	4.00	-	7.19	.010
" 7	2.00	3.62	4.25	-	5.86	.025
" 8	2.00	3.50	3.88	-	4.81	.050
" 9	1.88	3.75	4.00	-	12.86	.001
" 10	2.12	4.00	4.12	-	7.33	.010
" 11	2.12	4.12	3.75	-	7.06	.010
" 12	2.25	3.88	3.88	-	5.14	.025
" 13	2.12	3.88	3.88	-	5.44	.025
" 14	2.12	3.75	4.25	-	7.86	.010
" 15	2.12	4.12	4.12	-	8.00	.005
" 16	2.12	3.88	4.25	-	4.90	.025

TABLE 9
MEAN VALUES FOR HEART RATE

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	71.93	68.97	72.03	73.80	.71	N.S.
25 Minute Totals	76.88	75.35	75.38	75.68	.57	N.S.
2.5 Hour Totals	76.42	75.32	79.48	-	2.67	N.S.
Block 1	77.75	77.03	80.69	-	1.39	"
" 2	78.50	75.12	79.81	-	1.73	"
" 3	77.44	75.94	79.62	-	1.61	"
" 4	74.50	75.22	78.16	-	1.51	"
" 5	73.94	73.31	79.09	-	3.35	"
4.0 Hour Total	76.28	75.86	77.20	-	.21	N.S.
Block 1	79.53	80.22	82.56	-	.95	"
" 2	79.59	80.06	79.09	-	.07	"
" 3	78.19	76.34	76.78	-	.31	"
" 4	76.97	75.53	77.56	-	.32	"
" 5	72.53	72.84	76.34	-	.84	"
" 6	75.44	74.53	76.66	-	.42	"
" 7	74.28	74.31	74.16	-	.01	"
" 8	73.72	73.00	74.44	-	.19	"
8.0 Hour Totals	78.5	78.2	79.8	-	.66	N.S.
Block 1	81.3	78.8	82.9	-	2.12	"
" 2	80.2	80.2	82.6	-	.65	"
" 3	78.9	78.4	80.1	-	.20	"
" 4	78.4	78.1	80.7	-	.96	"
" 5	75.0	75.0	78.6	-	2.21	"
" 6	77.2	76.6	78.0	-	.20	"
" 7	74.8	74.0	77.9	-	1.15	"
" 8	76.1	75.1	78.1	-	.52	"
" 9	79.2	81.5	80.0	-	.76	"
" 10	83.0	84.9	82.3	-	1.07	"
" 11	80.9	81.1	80.9	-	.00	"
" 12	80.4	81.7	79.8	-	.61	"
" 13	79.0	75.3	78.2	-	2.81	"
" 14	78.8	75.2	79.7	-	2.91	"
" 15	76.9	77.2	78.6	-	.69	"
" 16	76.2	78.6	78.4	-	.58	"

TABLE 10
MEAN VALUES FOR (Δ) CHANGE IN KINESTHETIC SENSIVITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Means						
Palm	+.08	-.11	-.34	.02	1.64	N.S.
Finger	-.11	-.12	-.09	-.39	1.23	"
25 Minute Means						
Palm	-.06	-.13	-.04	-.28	1.00	N.S.
Finger	-.02	-.12	-.03	-.11	.19	"
2.5 Hour Means:						
Left Finger	-.37	-.46	-.03	-	.54	N.S.
Right Finger	.37	-.16	-.21	-	3.68	"
Left Palm	-.02	-.18	-.72	-	3.54	"
Right Palm	-.42	-.62	-.13	-	4.16	.05
4.0 Hour Means						
Left Finger	-.19	.04	-.09	-	.44	N.S.
Right Finger	-.04	.04	-.17	-	.44	"
Left Palm	.19	-.32	-.07	-	1.08	"
Right Palm	.06	.00	-.21	-	.52	"
8.0 Hour Means						
Left Finger	-.29	-.31	-.04	-	.62	N.S.
Right Finger	-.15	-.23	-.08	-	.21	"
Left Palm	.17	-.25	-.18	-	1.08	"
Right Palm	.04	.10	.08	-	.01	"

TABLE 11
MEAN VALUES FOR (Δ) CHANGE IN MANUAL DEXTERITY

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Means						
#Pins	.33	1.20	5.20	.00	2.71	N.S.
Grasp Time/#Pins	-.02	1.32	-.31	1.30	1.76	"
Position Time/#Pins	-.01	.26	.12	.03	.49	"
25 Minute Means						
#Pins	-1.12	-2.25	1.37	-1.25	2.18	N.S.
Grasp Time/#Pins	-.20	.52	.76	.86	.62	"
Position Time/#Pins	-.20	-.21	.66	.79	2.95	"
2.5 Hour Means						
#Pins	-1.25	-3.62	.12	-	1.98	N.S.
Grasp Time/#Pins	.02	-.12	-.04	-	5.24	.025
Position Time/#Pins	-.03	-.01	-.004	-	.35	N.S.
4.0 Hour Means						
#Pins	.38	.25	1.25	-	.07	N.S.
Grasp Time/#Pins	-0.00	-0.02	0.00	-	.10	"
Position Time/#Pins	-0.00	-0.02	0.02	-	.59	"
8.0 Hour Means						
#Pins	-0.50	1.25	0.88	-	.36	N.S.
Grasp Time/#Pins	0.02	0.02	0.06	-	2.24	"
Position Time/#Pins	0.05	-0.01	-0.01	-	1.78	"

TABLE 12
MEAN VALUES FOR (Δ) CHANGE IN FLICKER FUSION RATES

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Rate	-.18	-.30	-.06	-1.12	2.13	N.S.
25 Minute Rate	-2.8	-.82	-1.76	-1.14	.76	N.S.
2.5 Hour Rate	-5.52	-1.99	-2.61	-	1.30	N.S.
4.0 Hour Rate	-.02	-1.25	-2.89	-	.92	N.S.
8.0 Hour Rate	-3.31	-.99	-3.71	-	3.38	N.S.

TABLE 13
MEAN VALUES FOR (Δ) CHANGE IN VASOMOTOR REACTION TIME

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Means	-.08	-.02	-.12	-.14	.38	N.S.
25 Minute Means	-.27	-.19	-.17	-.04	1.04	N.S.
2.5 Hour Means						
Left Hand	.20	.39	.22	-	.80	N.S.
Right Hand	.31	.31	.15	-	1.04	"
4.0 Hour Means						
Left Hand	.23	.35	.22	-	.39	N.S.
Right Hand	.36	.29	.38	-	.30	"
8.0 Hour Means						
Left Hand	-.01	-.06	-.02	-	.12	N.S.
Right Hand	.12	-.09	.07	-	1.93	"

TABLE 14
MEAN VALUES FOR (Δ) CHANGE IN DYNAMOMETER

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Means	-.52	-.65	-.08	-1.46	3.83	.05
25 Minute Means	-1.30	-1.50	1.64	-.83	2.22	N.S.
2.5 Hour Means						
Left Hand	1.98	2.64	3.80	-	.16	N.S.
Right Hand	1.42	-.34	1.58	-	.75	"
4.0 Hour Means						
Left Hand	-1.42	-1.30	2.38	-	1.11	N.S.
Right Hand	-1.26	1.61	3.20	-	1.35	"
8.0 Hour Means						
Left Hand	-.78	2.50	3.60	-	2.38	N.S.
Right Hand	2.34	2.09	.28	-	.38	"

TABLE 15
MEAN VALUE FOR SPECIFIC GRAVITY - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Total	1.021	1.024	1.021	1.024	2.50	.10
Pre-Sample	1.020	1.024	1.021	1.024	3.00	.05
Post-Sample	1.023	1.024	1.020	1.024	1.50	N.S.
25 Minute Total	1.021	1.023	1.022	1.022	.50	N.S.
Pre-Sample	1.020	1.024	1.021	1.022	3.00	.05
Post-Sample	1.022	1.022	1.023	1.022	.00	N.S.
2.5 Hour Total	1.020	1.020	1.021	-	.42	N.S.
Pre-Sample	1.020	1.022	1.022	-	.50	"
Post-Sample	1.019	1.018	1.020	-	1.00	"
4.0 Hour Total	1.019	1.020	1.020	-	1.00	N.S.
Pre-Sample	1.022	1.020	1.021	-	.86	"
2Hr-Sample	1.018	1.021	1.021	-	4.28	.05
Post-Sample	1.016	1.015	1.016	-	.33	N.S.
8.0 Hour Total	1.021	1.016	1.017	-	13.50	.001
Pre-Sample	1.024	1.024	1.020	-	2.00	N.S.
2Hr-Sample	1.024	1.019	1.018	-	8.00	.005
4Hr-Sample	1.019	1.012	1.013	-	5.00	.025
6Hr-Sample	1.019	1.015	1.018	-	1.33	N.S.
Post-Sample	1.016	1.010	1.015	-	5.29	.025

TABLE 16
MEAN VALUES FOR pH REACTION - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	6.15	6.00	5.91	5.97	.15	N.S.
Pre-Sample	6.06	5.94	6.00	5.88	.07	"
Post-Sample	6.25	6.06	5.82	6.06	.38	"
25 Minute Totals	6.56	6.00	6.41	6.16	1.22	N.S.
Pre-Sample	6.44	5.75	6.25	6.06	.83	"
Post-Sample	6.69	6.25	6.56	6.25	1.10	"
2.5 Hour Totals	5.66	5.84	5.75	-	.22	N.S.
Pre-Sample	5.81	5.88	5.62	-	.24	"
Post-Sample	5.50	5.81	5.88	-	.61	"
4.0 Hour Totals	5.84	5.77	5.75	-	.10	N.S.
Pre-Sample	6.19	5.88	5.69	-	1.08	"
2Hr-Sample	5.75	6.06	5.88	-	.45	"
Post-Sample	5.62	5.38	5.69	-	1.77	"
8.0 Hour Totals	5.61	5.95	5.68	-	1.34	N.S.
Pre-Sample	5.56	5.44	5.56	-	.17	"
2Hr-Sample	5.62	6.00	5.44	-	1.96	"
4Hr-Sample	5.62	6.19	5.75	-	1.48	"
6Hr-Sample	5.62	6.19	6.00	-	1.34	"
Post-Sample	5.62	5.94	5.62	-	1.47	"

TABLE 17
MEAN VALUES FOR ALBUMIN - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	.020	.010	.020	.010	.59	N.S.
Pre-Sample	.010	.000	.020	.000	1.72	"
Post-Sample	.020	.020	.020	.010	.12	"
25 Minute Totals	.010	.010	.010	.010	.26	N.S.
Pre-Sample	.000	.020	.010	.010	.78	"
Post-Sample	.020	.000	.000	.000	2.31	"
2.5 Hour Totals	.044	.025	.000	-	.97	N.S.
Pre-Sample	.050	.000	.000	-	1.00	"
Post-Sample	.038	.050	.000	-	1.36	"
4.0 Hour Totals	.008	.008	.004	-	.15	N.S.
Pre-Sample	.025	.012	.012	-	.31	"
2Hr-Sample	.000	.012	.000	-	1.00	"
Post-Sample	.000	.000	.000	-	.00	"
8.0 Hour Totals	.005	.008	.010	-	.21	N.S.
Pre-Sample	.000	.025	.025	-	1.00	"
2Hr-Sample	.000	.012	.000	-	1.00	"
4Hr-Sample	.025	.000	.012	-	.57	"
6Hr-Sample	.000	.000	.012	-	1.00	"
Post-Sample	.000	.000	.000	-	.00	"

TABLE 18
MEAN VALUES FOR SUGAR - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	.00	.00	.00	.00	.00	N.S.
Pre-Sample	.00	.00	.00	.00	.00	"
Post-Sample	.00	.00	.00	.00	.00	"
25 Minute Totals	.00	.00	.00	.00	.00	N.S.
Pre-Sample	.00	.00	.00	.00	.00	"
Post-Sample	.00	.00	.00	.00	.00	"
2.5 Hour Totals	.00	.00	.00	.00	.00	N.S.
Pre-Sample	.00	.00	.00	.00	.00	"
Post-Sample	.00	.00	.00	.00	.00	"
4.0 Hour Totals	.00	.004	.004	.00	.47	N.S.
Pre-Sample	.00	.012	.000	.00	1.00	"
2Hr-Sample	.00	.000	.012	.00	1.00	"
Post-Sample	.00	.000	.000	.00	.00	"
8.0 Hour Totals	.00	.000	.002	.00	1.00	N.S.
Pre-Sample	.00	.000	.012	.00	1.00	"
2Hr-Sample	.00	.000	.012	.00	.00	"
4Hr-Sample	.00	.000	.000	.00	.00	"
6Hr-Sample	.00	.000	.000	.00	.00	"
Post-Sample	.00	.000	.000	.00	.00	"

TABLE 19
MEAN VALUES FOR WHITE BLOOD CELL COUNT - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	.56	.75	.25	.31	2.12	N.S.
Pre-Sample	.50	.75	.25	.38	1.24	"
Post-Sample	.62	.75	.25	.25	1.97	"
25 Minute Totals	1.38	2.12	2.44	1.00	2.23	N.S.
Pre-Sample	1.50	3.00	2.88	1.00	2.81	"
Post-Sample	1.25	1.25	2.00	1.00	1.17	"
2.5 Hour Totals	3.56	5.31	2.12	-	1.05	N.S.
Pre-Sample	3.88	2.75	2.00	-	1.25	"
Post-Sample	3.25	7.87	2.25	-	1.01	"
4.0 Hour Totals	1.88	1.42	1.04	-	.81	N.S.
Pre-Sample	2.38	1.88	1.38	-	.45	"
2Hr-Sample	1.50	1.00	.88	-	.53	"
Post-Sample	1.75	1.38	.88	-	1.98	"
8.0 Hour Totals	2.42	2.48	3.68	-	5.59	.025
Pre-Sample	3.25	3.50	4.62	-	.44	N.S.
2Hr-Sample	2.12	3.00	3.00	-	.29	"
4Hr-Sample	1.75	1.62	2.62	-	.54	"
6Hr-Sample	1.38	2.38	4.50	-	2.43	"
Post-Sample	3.62	1.88	3.62	-	.67	"

TABLE 20
MEAN VALUES FOR RED BLOOD CELL COUNT - URINALYSIS

MEASURE GROUPING	Vibration Conditions				F - Ratio	Significance Level
	0 Hz	2 Hz	4 Hz	8 Hz		
16 Minute Totals	1.00	.38	.38	.25	1.51	N.S.
Pre-Sample	.38	.25	.50	.25	.55	"
Post-Sample	1.62	.50	.25	.25	.53	"
25 Minute Totals	1.00	2.00	1.88	1.25	1.38	N.S.
Pre-Sample	1.12	3.12	1.75	1.38	3.33	.05
Post-Sample	.88	.88	2.00	1.12	.95	N.S.
2.5 Hour Totals	.56	.69	.50	-	.30	N.S.
Pre-Sample	.38	.50	.50	-	.06	"
Post-Sample	.75	.88	.50	-	.75	"
4.0 Hour Totals	.42	.17	.12	-	1.27	N.S.
Pre-Sample	.62	.38	.25	-	.43	"
2Hr-Sample	.38	.12	.12	-	.78	"
Post-Sample	.25	.00	.00	-	1.00	"
8.0 Hour Totals	.65	.48	.82	-	.27	N.S.
Pre-Sample	.75	.88	.88	-	.04	"
2Hr-Sample	1.12	.50	.88	-	.25	"
4Hr-Sample	.50	.12	.38	-	.50	"
6Hr-Sample	.50	.62	.75	-	.11	"
Post-Sample	.38	.25	1.25	-	1.93	"

TABLE 21
MEAN "g" VALUES FOR ACCELERATION TRANSMITTED
TO THE HEAD 2 HZ EXPOSURES

DURATION GROUPING	SAMPLES				F-Ratio	Significance Level	Mean
	1st	2nd	3rd	4th			
2.5 Hour Mean	.230	.229	.230	.234	1.26	N.S.	.231
Block 1	.244	.229	.233	.239	1.81	"	.236
" 2	.220	.224	.225	.226	.44	"	.224
" 3	.228	.230	.230	.231	.25	"	.230
" 4	.229	.228	.226	.235	1.43	"	.230
" 5	.229	.233	.234	.237	1.60	"	.233
4.0 Hour Mean	.176	.177	.178	.181	2.50	.05	.178
Block 1	.171	.166	.167	.176	2.50	N.S.	.170
" 2	.174	.172	.172	.183	3.25	"	.176
" 3	.173	.171	.179	.183	1.70	"	.176
" 4	.177	.179	.181	.185	1.20	"	.181
Block 5	.180	.181	.179	.184	.12	N.S.	.181
" 6	.177	.182	.181	.177	.50	"	.179
" 7	.176	.182	.187	.180	1.57	"	.181
" 8	.181	.180	.181	.181	.01	"	.181
8.0 Hour Mean	.108	.108	.108	.108	1.62	N.S.	.108
Block 1	.101	.103	.108	.102	1.57	"	.105
" 2	.107	.106	.103	.109	1.33	"	.106
" 3	.106	.106	.101	.105	1.25	"	.105
" 4	.108	.103	.105	.109	1.00	"	.103
Block 5	.108	.106	.102	.103	2.00	N.S.	.105
" 6	.104	.103	.102	.109	3.50	.05	.104
" 7	.108	.103	.104	.104	3.00	N.S.	.105
" 8	.104	.106	.106	.106	.50	"	.106
Block 9	.108	.109	.108	.108	.10	N.S.	.108
" 10	.108	.110	.110	.109	.25	"	.110
" 11	.109	.111	.114	.114	2.50	"	.112
" 12	.111	.114	.111	.107	.86	"	.111
Block 13	.109	.111	.112	.113	.66	N.S.	.111
" 14	.108	.109	.113	.112	1.50	"	.110
" 15	.110	.110	.108	.110	1.00	"	.110
" 16	.111	.108	.113	.107	2.50	"	.110

TABLE 22
MEAN "g" VALUES FOR ACCELERATION TRANSMITTED
TO THE HEAD 4 HZ EXPOSURES

DURATION GROUPING	SAMPLES				F-Ratio	Significance Level	Mean
	1st	2nd	3rd	4th			
2.5 Hour Mean	.248	.258	.258	.257	.35	N.S.	.256
Block 1	.265	.268	.254	.245	.45	"	.258
" 2	.234	.256	.266	.256	3.06	"	.253
" 3	.230	.259	.252	.247	1.72	"	.247
" 4	.257	.245	.266	.276	3.12	"	.261
" 5	.252	.265	.252	.260	.41	"	.257
4.0 Hour Mean	.162	.166	.170	.172	.83	N.S.	.168
Block 1	.173	.185	.194	.197	1.28	"	.187
" 2	.154	.169	.180	.165	4.86	.025	.167
" 3	.163	.167	.145	.172	2.79	N.S.	.161
" 4	.148	.154	.160	.148	.49	"	.151
Block 5	.176	.182	.166	.172	.36	N.S.	.174
" 6	.154	.156	.166	.176	2.24	"	.163
" 7	.160	.152	.185	.180	1.53	"	.169
" 8	.173	.166	.165	.163	.44	"	.167
8.0 Hour Mean	.094	.097	.099	.096	1.05	N.S.	.097
Block 1	.094	.089	.105	.086	1.96	"	.094
" 2	.090	.091	.086	.089	.44	"	.089
" 3	.092	.094	.098	.096	.33	"	.095
" 4	.084	.092	.105	.097	2.30	"	.094
Block 5	.093	.099	.097	.096	.50	N.S.	.097
" 6	.094	.089	.096	.098	.78	"	.094
" 7	.099	.096	.091	.099	1.37	"	.096
" 8	.100	.098	.099	.100	.08	"	.099
Block 9	.096	.106	.107	.100	1.91	N.S.	.102
" 10	.093	.099	.096	.101	.66	"	.097
" 11	.097	.089	.101	.090	1.83	"	.094
" 12	.088	.097	.099	.092	1.42	"	.094
Block 13	.108	.110	.112	.108	.18	N.S.	.109
" 14	.094	.104	.094	.097	1.23	"	.097
" 15	.097	.107	.099	.101	.44	"	.101
" 16	.096	.096	.092	.093	.57	"	.094

APPENDIX B
DATA TABLES FROM MID-FREQUENCY EXPERIMENTS
(C-5 MACHINE)

TABLE 1
MEAN VALUES FOR TOTAL TRACKING ERROR

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	94.45	108.32	100.45	3.80	.05
25 Minute Total	81.70	80.02	81.76	.14	N.S.
2.5 Hour Total	67.60	66.11	69.75	.50	N.S.
Block 1	64.29	65.87	72.97	1.34	"
" 2	67.92	64.55	71.37	1.37	"
" 3	70.25	62.22	65.47	1.93	"
" 4	70.40	68.46	72.94	.36	"
" 5	65.16	69.46	65.99	.74	"
4.0 Hour Total	72.52	70.62	69.01	2.59	N.S.
Block 1	68.71	69.35	71.32	.18	"
" 2	67.71	69.96	72.54	.32	"
" 3	71.31	68.52	69.01	.43	"
" 4	74.00	76.49	67.04	.90	"
" 5	72.96	68.84	65.76	2.83	"
" 6	73.92	68.97	66.42	1.07	"
" 7	77.46	73.72	72.72	.59	"
" 8	74.07	71.11	67.25	1.30	"
8.0 Hour Total	78.09	73.64	77.49	.06	N.S.
Block 1	72.94	72.09	64.00	2.48	"
" 2	71.20	72.26	71.21	.03	"
" 3	74.11	75.14	77.31	.07	"
" 4	72.17	72.87	73.31	.03	"
" 5	78.34	75.15	71.31	2.11	"
" 6	76.74	83.90	74.19	.76	"
" 7	81.35	82.86	76.44	.66	"
" 8	78.87	78.10	74.12	.35	"
" 9	75.25	77.28	77.52	.21	"
" 10	82.05	80.54	83.56	.13	"
" 11	83.02	86.14	84.51	.15	"
" 12	78.50	84.25	90.32	1.10	"
" 13	81.56	82.74	82.71	.03	"
" 14	80.54	80.21	77.90	.16	"
" 15	83.22	81.25	83.57	.15	"
" 16	79.62	73.54	77.89	1.05	"

TABLE 2
MEAN VALUES FOR REACTION TIME ON ATTENTIONAL SELECTIVITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	2.44	2.42	2.38	.28	N.S.
20° Light Totals	2.25	2.29	2.23	.24	"
35° " "	2.33	2.39	2.38	.15	"
50° " "	2.35	2.31	2.44	.70	"
65° " "	2.45	2.48	2.43	.14	"
80° " "	2.81	2.61	2.43	.68	"
25 Minute Total	3.77	3.83	3.81	.34	N.S.
20° Light Totals	3.56	3.60	3.64	.15	"
35° " "	3.76	3.86	3.71	2.82	.10
50° " "	3.81	3.85	3.74	.39	N.S.
65° " "	3.87	3.95	3.99	.28	"
80° " "	3.85	3.91	4.00	1.02	"
2.5 Hour Total	3.91	3.81	3.90	.57	N.S.
20° Light Totals	3.69	3.58	3.62	1.07	"
35° " "	3.74	3.75	3.79	.15	"
50° " "	4.00	3.89	3.97	.47	"
65° " "	3.97	3.90	3.92	.45	"
80° " "	4.14	3.93	4.23	.62	"
2.5 Hr. -Block 1 Total	3.76	3.71	4.13	2.87	.10
20° Light Totals	3.63	3.53	3.72	.76	N.S.
35° " "	3.58	3.69	3.83	1.58	"
50° " "	3.79	3.71	4.29	3.06	.10
65° " "	3.77	3.74	4.17	5.12	.025
80° " "	4.05	3.86	4.65	1.41	N.S.
2.5 Hr. -Block 3 Total	4.12	3.84	3.76	3.36	.10
20° Light Totals	3.80	3.59	3.50	2.72	N.S.
35° " "	3.92	3.68	3.81	1.14	"
50° " "	4.21	3.98	3.71	4.15	.05
65° " "	4.27	3.98	3.67	7.20	.01
80° " "	4.38	3.97	4.10	.58	N.S.
2.5 Hr. -Block 5 Total	3.85	3.89	3.83	.45	N.S.
20° Light Totals	3.66	3.64	3.62	.05	"
35° " "	3.72	3.90	3.71	1.79	"
50° " "	4.00	3.96	3.92	.17	"
65° " "	3.86	3.98	3.93	.62	"
80° " "	4.01	3.97	3.94	.15	"
4.0 Hour Total	4.08	3.94	3.91	1.14	N.S.
20° Light Total	3.76	3.68	3.71	1.12	"
35° " "	3.82	3.72	3.80	.26	"
50° " "	4.07	4.13	4.06	.16	"
65° " "	4.32	4.12	4.00	1.16	"
80° " "	4.45	4.06	3.98	3.40	.10
4.0 Hr. -Block 2 Total	3.82	3.86	4.16	.83	N.S.
20° Light Totals	3.63	3.63	3.97	.83	"
35° " "	3.71	3.49	3.85	.78	"
50° " "	3.85	4.03	4.36	.89	"
65° " "	3.85	4.14	4.29	1.18	"
80° " "	4.03	4.00	4.33	.40	"

TABLE 2 (Continued)

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
4.0 Hr. -Block 4 Total	4.16	4.02	3.82	.69	N.S.
20° Light Totals	3.73	3.72	3.62	.17	"
35° " "	3.85	3.68	3.83	.27	"
50° " "	4.13	4.32	3.92	.40	"
65° " "	4.43	4.41	3.92	.97	"
80° " "	4.66	3.98	3.81	2.36	"
4.0 Hr. -Block 6 Total	4.14	3.99	3.79	.86	N.S.
20° Light Totals	3.84	3.70	3.56	1.83	"
35° " "	3.79	3.80	3.75	.04	"
50° " "	4.08	4.21	3.89	.66	"
65° " "	4.94	3.91	3.86	1.61	"
80° " "	4.05	4.33	3.88	1.37	"
4.0 Hr. -Block 8 Total	4.22	3.90	3.87	1.67	N.S.
20° Light Totals	3.86	3.68	3.70	.79	"
35° " "	3.93	3.90	3.75	.49	"
50° " "	4.20	3.96	4.09	.62	"
65° " "	4.08	4.03	3.95	.09	"
80° " "	5.05	3.92	3.88	2.06	"
8.0 Hour Total	4.13	4.31	4.11	.98	N.S.
20° Light Totals	3.84	3.98	3.86	.81	"
35° " "	3.98	4.11	3.99	1.42	"
50° " "	4.21	4.37	4.13	1.48	"
65° " "	4.14	4.50	4.31	5.99	.025
80° " "	4.47	4.59	4.24	2.33	N.S.
8.0 Hr. -Block 2 Total	3.86	3.97	3.95	.34	N.S.
20° Light Totals	3.70	3.67	3.68	.01	"
35° " "	3.79	3.92	3.87	.34	"
50° " "	3.92	3.98	4.05	.15	"
65° " "	3.86	4.40	3.98	1.14	"
80° " "	4.00	4.76	4.05	1.59	"
8.0 Hr. -Block 4 Total	3.84	4.18	3.91	1.82	N.S.
20° Light Totals	3.64	3.86	3.61	1.29	"
35° " "	3.78	3.91	3.87	.34	"
50° " "	3.92	3.98	4.04	.15	"
65° " "	3.86	4.01	3.90	1.14	"
80° " "	3.99	4.76	4.04	1.59	"
8.0 Hr. -Block 6 Total	4.00	4.28	3.91	1.27	N.S.
20° Light Totals	3.88	3.98	3.67	1.93	"
35° " "	3.96	3.67	3.88	.20	"
50° " "	4.00	4.18	3.85	1.14	"
65° " "	4.06	4.62	4.08	1.11	"
80° " "	4.13	4.68	4.07	1.26	"
8.0 Hr. -Block 8 Total	4.00	4.53	3.88	1.70	N.S.
20° Light Totals	3.78	4.26	3.63	3.05	.10
35° " "	3.94	4.26	3.76	1.75	N.S.
50° " "	3.96	5.02	4.04	1.32	"
65° " "	4.05	4.53	3.99	1.53	"
80° " "	4.27	4.57	3.96	.99	"

TABLE 2 (Continued)

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
8.0 Hr. -Block 10 Total	4.44	4.80	4.57	.28	N.S.
20° Light Totals	3.87	4.07	4.30	1.27	"
35° " "	4.18	4.58	4.48	.63	"
50° " "	4.52	4.91	4.53	.83	"
65° " "	4.52	4.91	4.58	.23	"
80° " "	5.09	5.23	4.68	.48	"
8.0 Hr. -Block 12 Total	4.48	4.51	4.58	.08	N.S.
20° Light Totals	3.97	3.96	4.04	.16	"
35° " "	4.08	4.15	4.61	.80	"
50° " "	5.24	4.68	4.77	.94	"
65° " "	4.17	4.83	4.88	.92	"
80° " "	4.92	4.94	4.59	1.40	"
8.0 Hr. -Block 14 Total	4.34	4.25	4.13	.50	N.S.
20° Light Totals	3.89	4.22	3.80	.83	"
35° " "	3.97	4.17	3.89	1.81	"
50° " "	4.08	4.12	4.22	.83	"
65° " "	4.34	4.45	4.50	.15	"
80° " "	5.44	4.31	4.26	1.37	"
8.0 Hr. -Block 16 Total	4.09	3.98	3.92	2.13	N.S.
20° Light Totals	3.95	3.84	3.68	3.06	.10
35° " "	3.96	3.85	3.79	1.44	N.S.
50° " "	4.06	3.92	3.93	1.13	"
65° " "	4.25	4.37	4.07	.78	"
80° " "	4.22	3.90	4.13	1.23	"

TABLE 3
MEAN VALUES FOR AUDITORY VIGILANCE TASK

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
2.5 Hour Mean Total					
# Yes Responses	10.81	12.31	10.69	1.41	N.S.
Block 2	10.50	12.88	11.00	1.99	"
" 4	11.12	11.75	10.38	.46	"
# Inventions	4.81	5.56	4.00	.40	N.S.
Block 2	5.00	6.00	4.00	.84	"
" 4	4.62	5.12	4.00	.12	"
% Correct	.65	.71	.65	.55	N.S.
Block 2	.67	.74	.70	.77	"
" 4	.65	.67	.61	.41	"
4.0 Hour Mean Total					
# Yes Responses	9.31	10.31	9.66	1.65	N.S.
Block 1	9.12	9.88	8.12	3.29	.10
" 3	9.00	10.62	10.25	2.23	N.S.
" 5	9.38	9.75	9.38	.08	"
" 7	9.75	11.00	10.88	1.23	"
# Inventions	2.34	2.43	2.34	.01	N.S.
Block 1	2.25	2.00	3.75	1.70	"
" 3	1.25	2.38	1.25	1.25	"
" 5	2.50	2.62	2.00	.18	"
" 7	3.38	2.75	2.38	.22	"
% Correct	.55	.62	.58	2.20	N.S.
Block 1	.57	.61	.51	2.92	.10
" 3	.52	.64	.60	4.56	.05
" 5	.56	.59	.59	.20	N.S.
" 7	.56	.65	.65	2.30	"
8.0 Hour Mean Total					
# Yes Responses	9.09	8.74	8.11	1.40	N.S.
Block 1	7.88	7.75	7.00	3.82	.05
" 3	9.12	9.12	8.88	.03	N.S.
" 5	9.00	8.88	7.50	1.47	"
" 7	9.12	9.12	10.00	.31	"
" 9	9.75	8.12	7.62	3.07	.10
" 11	9.38	8.88	8.12	.60	N.S.
" 13	8.00	9.75	7.75	2.13	"
" 15	10.50	8.25	8.00	3.08	.10
# Inventions	2.31	2.53	1.81	.82	N.S.
Block 1	2.00	2.75	1.38	1.74	"
" 3	1.50	2.00	1.50	.61	"
" 5	3.00	2.75	1.50	.86	"
" 7	2.12	2.25	1.38	.38	"
" 9	3.00	3.25	2.38	.26	"
" 11	2.62	2.62	1.88	.14	"
" 13	2.25	2.12	2.00	.05	"
" 15	2.00	2.50	2.50	.20	"

TABLE 3 (Continued)

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
% Correct	.56	.53	.49	1.82	N.S.
Block 1	.51	.48	.45	.44	"
" 3	.54	.54	.54	.01	"
" 5	.54	.55	.45	2.39	"
" 7	.56	.55	.60	.28	"
" 9	.61	.51	.48	4.04	.05
" 11	.56	.54	.48	.82	N.S.
" 13	.50	.58	.47	1.97	"
" 15	.64	.49	.48	3.18	.10

TABLE 4
MEAN VALUES FOR TASK DIFFICULTY RATINGS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	3.38	5.62	5.25	6.76	.01
25 Minute Total	4.12	4.38	5.62	3.94	.05
2.5 Hour Total	3.52	4.62	5.00	10.49	.005
Block 1	3.00	4.38	4.50	7.10	.01
" 2	3.88	5.00	5.12	5.09	.025
" 3	3.75	4.38	4.88	3.46	.10
" 4	3.62	4.75	5.12	9.00	.005
" 5	3.38	4.62	5.38	9.27	.005
4.0 Hour Total	3.73	4.45	4.58	5.48	.025
Block 1	3.62	4.12	4.88	3.41	.10
" 2	3.38	4.00	4.12	3.34	.10
" 3	3.62	4.38	4.75	4.55	.05
" 4	3.50	4.38	4.50	4.58	.05
" 5	3.75	4.50	4.88	6.78	.01
" 6	3.75	4.62	4.38	1.99	N.S.
" 7	4.00	4.88	4.62	3.07	"
" 8	4.25	4.75	4.50	.60	"
8.0 Hour Total	4.14	4.08	4.53	1.97	N.S.
Block 1	4.12	3.75	4.25	.93	"
" 2	4.38	3.75	4.12	1.56	"
" 3	4.50	4.00	4.62	2.19	"
" 4	3.75	3.88	4.38	2.49	"
" 5	4.12	4.00	4.50	1.35	"
" 6	4.00	4.00	4.38	1.34	"
" 7	4.50	4.00	4.75	4.45	.05
" 8	4.25	4.00	4.25	.54	N.S.
" 9	3.88	4.00	4.75	2.26	"
" 10	4.12	4.00	4.38	.26	"
" 11	4.12	4.38	4.50	.34	"
" 12	4.12	4.12	4.75	1.16	"
" 13	3.88	4.12	4.50	1.56	"
" 14	3.88	4.12	4.62	1.48	"
" 15	4.50	4.62	4.88	.50	"
" 16	4.12	4.62	4.88	2.58	"

TABLE 5
MEAN VALUES FOR VISUAL ACUTTY COMPLETION TIMES

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	51.6	52.2	55.5	1.71	N.S.
25 Minute Total	51.8	50.8	54.4	2.98	N.S.
2.5 Hour Total	51.0	51.3	49.1	1.66	N.S.
Block 1	49.8	51.1	47.8	.80	"
" 2	50.8	51.8	47.7	2.88	"
" 3	51.7	51.4	48.9	1.72	"
" 4	51.2	51.4	50.8	.07	"
" 5	51.4	51.0	50.4	.14	"
4.0 Hour Total	50.5	49.6	49.6	.91	N.S.
Block 1	49.7	48.6	49.0	.24	"
" 2	50.1	49.5	48.1	.99	"
" 3	50.4	49.6	48.6	.75	"
" 4	51.0	47.6	49.25	1.54	"
" 5	51.1	49.0	49.9	.69	"
" 6	52.0	48.2	50.8	1.57	"
" 7	50.8	52.6	52.2	.31	"
" 8	48.8	50.5	49.4	.56	"
8.0 Hour Total	47.7	49.0	49.5	1.11	N.S.
Block 1	47.0	48.4	47.0	.49	"
" 2	48.1	47.0	47.5	.10	"
" 3	46.6	50.4	49.1	2.07	"
" 4	48.2	48.5	50.2	.60	"
" 5	45.6	50.4	49.5	5.62	.025
" 6	45.8	48.8	49.5	2.40	N.S.
" 7	46.5	50.5	48.5	1.10	"
" 8	47.5	49.1	49.1	.42	"
" 9	47.2	50.2	49.7	.64	"
" 10	48.4	47.8	50.5	.94	"
" 11	47.7	49.0	49.0	.24	"
" 12	47.8	50.0	49.9	.48	"
" 13	48.4	47.5	51.1	1.47	"
" 14	49.6	48.5	49.6	.18	"
" 15	51.4	50.1	51.6	.26	"
" 16	47.6	48.2	50.6	1.18	"

TABLE 6
MEAN VALUES FOR 12 POSITIONS # CORRECT/36 ON VISUAL ACUITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	.78	.73	.64	3.78	.05
25 Minute Total	.76	.75	.69	1.32	N.S.
2.5 Hour Total	.74	.73	.77	.20	N.S.
Block 1	.75	.73	.73	.02	"
" 2	.76	.73	.82	.76	"
" 3	.75	.70	.78	.36	"
" 4	.73	.78	.79	.35	"
" 5	.70	.70	.72	.03	"
4.0 Hour Total	.71	.77	.74	2.34	N.S.
Block 1	.69	.78	.73	3.22	.10
" 2	.77	.76	.78	.16	N.S.
" 3	.72	.78	.74	.69	"
" 4	.75	.76	.75	.06	"
" 5	.68	.76	.74	2.09	"
" 6	.66	.78	.73	2.05	"
" 7	.75	.75	.74	.02	"
" 8	.70	.76	.69	1.12	"
8.0 Hour Total	.85	.79	.84	1.13	N.S.
Block 1	.88	.80	.87	1.05	"
" 2	.88	.82	.92	12.29	.001
" 3	.87	.80	.82	1.12	N.S.
" 4	.84	.78	.82	1.62	"
" 5	.83	.80	.86	.83	"
" 6	.83	.80	.90	1.38	"
" 7	.84	.78	.83	1.05	"
" 8	.84	.78	.83	.48	"
" 9	.84	.74	.84	.99	"
" 10	.85	.74	.80	1.33	"
" 11	.84	.78	.86	.69	"
" 12	.87	.79	.78	1.31	"
" 13	.84	.82	.83	.09	"
" 14	.82	.81	.82	.01	"
" 15	.81	.80	.83	.06	"
" 16	.88	.76	.78	2.14	"

TABLE 7
MEAN VALUES FOR 4 POSITION # CORRECT/12 ON VISUAL ACUITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	.83	.82	.74	1.96	N.S.
25 Minute Total	.84	.76	.78	.54	N.S.
2.5 Hour Total	.78	.76	.82	.33	N.S.
Block 1	.82	.74	.76	.29	"
" 2	.79	.80	.84	.12	"
" 3	.78	.74	.86	.73	"
" 4	.73	.79	.85	1.12	"
" 5	.77	.75	.77	.05	"
4.0 Hour Total	.76	.81	.78	2.46	N.S.
Block 1	.80	.86	.78	1.76	"
" 2	.82	.79	.83	.54	"
" 3	.79	.81	.82	.20	"
" 4	.79	.81	.78	.18	"
" 5	.64	.82	.79	4.22	.05
" 6	.67	.81	.78	1.77	N.S.
" 7	.78	.77	.78	.02	"
" 8	.79	.82	.71	2.69	"
8.0 Hour Total	.89	.81	.90	1.96	N.S.
Block 1	.91	.80	.92	1.09	"
" 2	.88	.90	.93	.56	"
" 3	.93	.80	.93	3.53	.10
" 4	.84	.81	.86	.66	N.S.
" 5	.90	.88	.90	.10	"
" 6	.84	.84	.96	1.88	"
" 7	.89	.81	.91	1.79	"
" 8	.93	.82	.90	.92	"
" 9	.84	.76	.94	2.16	"
" 10	.84	.75	.88	1.06	"
" 11	.95	.76	.90	2.10	"
" 12	.93	.75	.86	3.00	.10
" 13	.89	.89	.87	.05	N.S.
" 14	.89	.85	.88	.08	"
" 15	.85	.86	.92	1.02	"
" 16	.89	.74	.84	1.69	"

TABLE 8
MEAN VALUES FOR MOTION SEVERITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	1.25	5.25	6.50	49.54	.001
25 Minute Total	1.75	4.88	6.12	22.44	.001
2.5 Hour Total	2.08	5.08	5.78	25.31	.001
Block 1	1.88	5.25	5.62	31.67	.001
" 2	2.00	5.00	5.62	19.19	.001
" 3	1.88	5.12	5.75	29.94	.001
" 4	2.25	5.00	6.00	16.45	.001
" 5	2.38	5.00	5.88	17.23	.001
4.0 Hour Total	1.88	4.91	5.22	20.03	.001
Block 1	1.75	4.62	5.12	17.22	.001
" 2	1.75	4.50	4.88	15.73	.001
" 3	2.00	4.88	5.00	10.78	.001
" 4	1.75	5.12	5.25	24.26	.001
" 5	1.87	5.00	5.12	16.54	.001
" 6	1.87	4.87	5.25	18.03	.001
" 7	1.87	5.00	5.50	25.55	.001
" 8	2.12	5.25	5.62	25.46	.001
8.0 Hour Total	2.00	4.56	5.10	14.09	.001
Block 1	2.00	4.38	5.00	10.30	.005
" 2	2.00	4.37	5.00	10.05	.005
" 3	1.87	4.50	5.12	12.33	.001
" 4	1.87	4.38	5.25	13.79	.001
" 5	1.87	4.50	5.12	16.41	.001
" 6	2.12	4.50	5.00	11.87	.001
" 7	2.00	4.50	5.12	11.97	.001
" 8	2.25	4.38	5.00	7.56	.010
" 9	1.75	4.38	5.25	17.81	.001
" 10	1.88	4.50	5.00	13.01	.001
" 11	2.00	4.62	5.00	10.27	.005
" 12	2.00	4.75	5.25	15.36	.001
" 13	2.00	4.62	4.88	10.62	.005
" 14	2.12	4.75	5.12	12.51	.001
" 15	2.12	4.88	5.25	14.37	.001
" 16	2.12	5.00	5.25	18.36	.001

TABLE 9
MEAN VALUES FOR HEART RATE

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	76.0	82.5	82.0	1.48	N.S.
25 Minute Total	78.7	78.4	81.3	.60	N.S.
2.5 Hour Total	83.2	86.4	85.2	.80	N.S.
Block 1	84.5	88.1	87.1	.49	"
" 2	85.0	87.5	85.8	.33	"
" 3	83.6	86.1	85.4	.50	"
" 4	82.3	83.6	84.4	.35	"
" 5	80.5	86.9	83.1	2.01	"
4.0 Hour Total	82.4	85.9	86.7	1.60	N.S.
Block 1	83.8	89.8	90.1	2.05	"
" 2	84.5	88.4	88.8	.77	"
" 3	82.6	87.2	87.3	2.38	"
" 4	81.4	85.0	87.6	2.64	"
" 5	81.9	84.9	84.4	.57	"
" 6	81.0	82.9	84.7	.95	"
" 7	80.9	83.2	84.8	.74	"
" 8	82.8	85.8	85.6	.76	"
8.0 Hour Total	69.9	79.8	76.2	1.05	N.S.
Block 1	70.9	81.2	83.5	1.37	"
" 2	69.5	79.7	82.9	1.52	"
" 3	69.3	78.6	79.8	1.05	"
" 4	68.1	78.7	78.6	1.24	"
" 5	67.0	77.0	75.6	.87	"
" 6	66.8	77.5	79.2	1.59	"
" 7	68.6	78.8	79.7	1.17	"
" 8	71.8	79.6	79.8	.56	"
" 9	71.3	82.5	74.8	.96	"
" 10	72.2	85.1	75.2	1.02	"
" 11	71.6	83.2	75.5	.83	"
" 12	71.1	80.1	74.8	.66	"
" 13	69.6	77.2	69.1	.61	"
" 14	69.8	79.2	70.6	.75	"
" 15	69.8	78.9	69.9	.75	"
" 16	70.8	79.8	69.8	.94	"

TABLE 10
MEAN VALUES FOR (Δ) CHANGE IN KINESTHETIC SENSIVITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Means					
Left Finger	.02	.06	.00	.02	N.S.
Right Finger	-.29	-.08	-.13	.72	"
Left Palm	.01	.30	.33	.65	"
Right Palm	.03	-.16	.13	.60	"
25 Minute Means					
Left Finger	.01	-.02	.08	.24	N.S.
Right Finger	-.00	.04	-.06	.22	"
Left Palm	.21	-.06	.10	.49	"
Right Palm	-.12	.12	.50	2.02	"
2.5 Hour Means					
Left Finger	-.20	.48	.25	2.64	N.S.
Right Finger	-.14	-.10	-.36	.72	"
Left Palm	-.21	.04	.06	1.86	"
Right Palm	-.35	.06	.00	2.59	"
4.0 Hour Means					
Left Finger	-.31	-.19	-.02	1.54	N.S.
Right Finger	-.04	-.22	-.23	.76	"
Left Palm	.25	-.25	.12	1.45	"
Right Palm	-.21	.04	-.21	.44	"
8.0 Hour Means					
Left Finger	-.12	-.29	.12	1.97	N.S.
Right Finger	.14	-.02	-.23	2.58	"
Left Palm	.00	-.37	-.27	1.00	"
Right Palm	.31	.02	-.27	1.47	"

TABLE 11
MEAN VALUES FOR (Δ) CHANGE IN MANUAL DEXTERITY

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Means					
# Pins	-0.37	0.50	-1.75	.36	N.S.
Position Time/ Pins	-0.01	-0.02	0.01	1.11	"
Grasp Time/ Pins	0.01	-0.02	0.04	.91	"
25 Minute Means					
# Pins	2.38	1.50	1.75	.13	N.S.
Position Time/ Pins	-0.02	-0.12	0.01	1.30	"
Grasp Time/ Pins	-0.00	-0.01	-0.01	.06	"
2.5 Hour Means					
# Pins	-0.62	2.00	-0.50	.85	N.S.
Position Time/ Pins	0.01	-0.01	0.00	.50	"
Grasp Time/ Pins	0.01	-0.04	0.02	1.46	"
4.0 Hour Means					
# Pins	0.50	-0.88	-0.88	.29	N.S.
Position Time/ Pins	0.01	0.01	0.01	.24	"
Grasp Time/ Pins	-0.01	0.01	0.02	1.56	"
8.0 Hour Means					
# Pins	-0.37	0.12	2.88	1.37	N.S.
Position Time/ Pins	0.02	0.01	0.01	.92	"
Grasp Time/ Pins	-0.00	0.01	-0.02	.55	"

TABLE 12
MEAN VALUES FOR (Δ) CHANGE IN FLICKER FUSION RATES

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Rate	-0.81	-0.93	-1.76	.31	N.S.
25 Minute Rate	-0.02	-1.75	-0.92	1.17	N.S.
2.5 Hour Rate	-1.96	-2.39	-1.55	1.13	N.S.
4.0 Hour Rate	-0.69	-1.41	-1.48	.22	N.S.
8.0 Hour Rate	-1.51	-2.19	-3.48	2.28	N.S.

TABLE 13
MEAN VALUES FOR (Δ) CHANGE IN VASOMOTOR REACTION TIME

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Means					
Left Hand	-0.06	0.02	-0.03	1.42	N.S.
Right Hand	-0.06	-0.03	-0.01	.45	"
25 Minute Means					
Left Hand	-0.10	-0.05	0.03	3.55	.10
Right Hand	-0.01	-0.02	0.02	.24	N.S.
2.5 Hour Means					
Left Hand	0.12	-0.12	-0.01	6.80	.01
Right Hand	0.06	-0.04	0.14	3.33	.10
4.0 Hour Means					
Left Hand	-0.05	0.06	-0.16	1.62	N.S.
Right Hand	-0.02	0.09	0.05	1.04	"
8.0 Hour Means					
Left Hand	-0.06	-0.14	-0.01	.37	N.S.
Right Hand	-0.02	-0.02	0.02	.11	"

TABLE 14
MEAN VALUES FOR (Δ) CHANGE IN DYNAMOMETER

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Means					
Left Hand	1.20	-1.11	-0.61	.82	N.S.
Right Hand	1.36	0.71	-0.14	.30	"
25 Minute Means					
Left Hand	0.06	-2.35	1.34	1.41	N.S.
Right Hand	0.06	1.16	0.85	.06	"
2.5 Hour Means					
Left Hand	0.58	2.90	2.19	.92	N.S.
Right Hand	0.56	0.91	-0.76	.47	"
4.0 Hour Means					
Left Hand	0.06	0.56	1.28	.44	N.S.
Right Hand	-0.73	-0.30	-0.26	.05	"
8.0 Hour Means					
Left Hand	2.98	0.70	0.88	1.32	N.S.
Right Hand	2.28	0.64	1.91	.44	"

TABLE 15
MEAN VALUE FOR SPECIFIC GRAVITY - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	1.023	1.024	1.022	.50	N.S.
Pre-Sample Means	1.022	1.024	1.022	.25	"
Post-Sample Means	1.023	1.024	1.021	.67	"
25 Minute Total	1.022	1.022	1.018	.86	N.S.
Pre-Sample Means	1.022	1.023	1.020	.40	"
Post-Sample Means	1.022	1.022	1.017	2.00	"
2.5 Hour Total	1.019	1.021	1.022	.60	N.S.
Pre-Sample Means	1.020	1.021	1.023	.67	"
Post-Sample Means	1.018	1.020	1.022	1.00	"
4.0 Hour Total	1.021	1.025	1.024	3.00	.10
Pre-Sample Means	1.021	1.025	1.027	3.00	.10
2 Hr-Sample Means	1.023	1.027	1.026	.67	N.S.
Post-Sample Means	1.018	1.023	1.021	1.50	"
8.0 Hour Total	1.019	1.021	1.020	1.00	N.S.
Pre-Sample Means	1.022	1.025	1.023	1.50	"
2 Hr-Sample Means	1.020	1.023	1.021	.67	"
4 Hr-Sample Means	1.014	1.017	1.015	1.00	"
6 Hr-Sample Means	1.018	1.021	1.020	1.00	"
Post-Sample Means	1.019	1.013	1.013	0.00	"

TABLE 16
MEAN VALUES FOR pH REACTION - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	5.88	5.91	6.06	.22	N.S.
Pre-Sample Means	5.69	5.81	6.12	1.31	"
Post-Sample Means	6.06	6.00	6.00	.02	"
25 Minute Total	5.75	6.03	5.97	1.21	N.S.
Pre-Sample Means	5.81	5.94	5.94	.33	"
Post-Sample Means	5.69	6.12	6.00	1.36	"
2.5 Hour Total	5.75	5.41	5.59	1.41	N.S.
Pre-Sample Means	5.56	5.31	5.62	1.48	"
Post-Sample Means	5.94	5.50	5.56	1.32	"
4.0 Hour Total	5.83	5.81	5.79	.03	N.S.
Pre-Sample Means	5.69	5.88	5.94	.47	"
2 Hr-Sample Means	6.19	5.94	5.94	.93	"
Post-Sample Means	5.62	5.62	5.50	.28	"
8.0 Hour Total	5.65	5.72	5.94	2.10	N.S.
Pre-Sample Means	5.38	5.44	5.69	1.20	"
2 Hr-Sample Means	5.31	5.31	6.12	1.38	"
4 Hr-Sample Means	5.81	5.62	5.88	.51	"
6 Hr-Sample Means	5.88	5.81	6.19	.34	"
Post-Sample Means	5.38	5.94	5.31	5.04	.025

TABLE 17
MEAN VALUES FOR ALBUMIN - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
25 Minute Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
2.5 Hour Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
4.0 Hour Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
2 Hr-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
8.0 Hour Total	0.00	0.002	0.00	1.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
2 Hr-Sample Means	0.00	0.00	0.00	0.00	"
4 Hr-Sample Means	0.00	0.01	0.00	1.00	"
6 Hr-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"

TABLE 18
MEAN VALUES FOR SUGAR - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
25 Minute Total	0.00	0.00	0.00	0.00	N.S.
Pre-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"
2.5 Hour Total	0.38	0.00	0.12	1.96	N.S.
Pre-Sample Means	0.62	0.00	0.25	1.92	"
Post-Sample Means	0.12	0.00	0.00	1.00	"
4.0 Hour Total	0.00	0.04	0.00	1.00	N.S.
Pre-Sample Means	0.00	0.06	0.00	1.00	"
2 Hr-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.06	0.00	1.00	"
8.0 Hour Total	0.00	0.01	0.01	1.00	N.S.
Pre-Sample Means	0.00	0.00	0.06	1.00	"
2 Hr-Sample Means	0.00	0.00	0.00	0.00	"
4 Hr-Sample Means	0.00	0.06	0.00	1.00	"
6 Hr-Sample Means	0.00	0.00	0.00	0.00	"
Post-Sample Means	0.00	0.00	0.00	0.00	"

TABLE 19
MEAN VALUES FOR WHITE BLOOD CELL COUNT - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	1.19	3.75	1.56	.96	N.S.
Pre-Sample Means	1.12	6.12	1.62	1.08	"
Post-Sample Means	1.25	1.38	1.50	.09	"
25 Minute Total	2.56	1.44	1.81	.48	N.S.
Pre-Sample Means	3.00	1.50	1.62	.73	"
Post-Sample Means	2.12	1.38	2.00	.31	"
2.5 Hour Total	4.62	2.88	2.50	1.16	N.S.
Pre-Sample Means	4.88	3.25	2.50	.93	"
Post-Sample Means	4.38	2.50	2.50	1.37	"
4.0 Hour Total	3.29	1.75	2.12	1.87	N.S.
Pre-Sample Means	4.25	2.38	3.00	1.14	"
2 Hr-Sample Means	2.50	1.75	1.88	1.42	"
Post-Sample Means	3.12	1.12	1.50	2.32	"
8.0 Hour Total	2.10	1.70	1.48	.32	N.S.
Pre-Sample Means	2.62	2.88	1.38	1.73	"
2 Hr-Sample Means	2.25	1.00	1.62	.41	"
4 Hr-Sample Means	2.00	1.75	1.62	.12	"
6 Hr-Sample Means	1.75	1.62	1.88	.06	"
Post-Sample Means	1.88	1.25	.88	1.23	"

TABLE 20
MEAN VALUES FOR RED BLOOD CELL COUNT - URINALYSIS

MEASURE GROUPING	Vibration Conditions			F-Ratio	Significance Level
	0 Hz	8 Hz	16 Hz		
16 Minute Total	0.06	0.69	0.44	2.95	.10
Pre-Sample Means	0.00	0.75	0.50	3.77	.05
Post-Sample Means	0.12	0.62	0.38	1.91	N.S.
25 Minute Total	0.38	0.44	0.50	0.21	N.S.
Pre-Sample Means	0.38	0.38	0.38	0.00	"
Post-Sample Means	0.38	0.50	0.62	0.57	"
2.5 Hour Total	1.25	0.62	0.56	1.86	N.S.
Pre-Sample Means	1.62	0.75	0.62	1.73	"
Post-Sample Means	0.88	0.50	0.50	0.61	"
4.0 Hour Total	0.83	0.50	0.79	0.59	N.S.
Pre-Sample Means	1.12	0.38	0.75	2.03	"
2 Hr-Sample Means	0.50	0.62	0.75	0.25	"
Post-Sample Means	0.88	0.50	0.88	0.61	"
8.0 Hour Total	0.80	0.62	0.52	0.30	N.S.
Pre-Sample Means	0.88	0.50	0.62	0.37	"
2 Hr-Sample Means	0.38	0.50	0.50	0.66	"
4 Hr-Sample Means	0.62	0.50	0.62	0.09	"
6 Hr-Sample Means	0.75	0.75	0.50	0.69	"
Post-Sample Means	0.88	0.88	0.38	0.93	"

TABLE 21
MEAN "g" VALUES FOR ACCELERATION TRANSMITTED
TO THE HEAD 8 HZ EXPOSURES

DURATION GROUPING	SAMPLES				F-Ratio	Significance Level	Mean
	1st	2nd	3rd	4th			
16 Minute Mean	.548	.666	.709	-	52.55	.001	.641
25 Minute Mean	.456	.490	.493	.481	.52	N.S.	.523
2.5 Hour Mean	.197	.203	.208	.204	.99	N.S.	.203
Block 1	.201	.201	.193	.207	.88	N.S.	.201
" 2	.181	.205	.218	.216	3.24	.05	.205
" 3	.211	.207	.223	.199	.79	N.S.	.201
" 4	.191	.203	.205	.191	.71	"	.198
" 5	.198	.197	.201	.205	.22	"	.200
4.0 Hour Mean	.182	.187	.177	.183	1.10	N.S.	.182
Block 1	.162	.168	.172	.169	.54	"	.168
" 2	.180	.189	.185	.189	.42	"	.186
" 3	.184	.187	.186	.191	.05	"	.187
" 4	.196	.199	.189	.185	1.36	"	.192
Block 5	.171	.178	.163	.186	.99	"	.175
" 6	.194	.197	.175	.181	1.00	"	.187
" 7	.172	.171	.166	.185	1.30	"	.174
" 8	.197	.202	.182	.174	4.60	.025	.189
8.0 Hour Mean	.124	.123	.122	.125	.56	N.S.	.124
Block 1	.115	.111	.122	.112	.52	"	.115
" 2	.117	.114	.128	.111	2.40	"	.118
" 3	.107	.110	.117	.123	1.07	"	.114
" 4	.125	.127	.122	.124	.10	"	.125
Block 5	.120	.108	.119	.117	.61	N.S.	.116
" 6	.126	.136	.112	.121	2.62	"	.124
" 7	.112	.126	.124	.143	.89	"	.126
" 8	.124	.129	.124	.122	.12	"	.125
Block 9	.120	.122	.128	.129	.68	N.S.	.125
" 10	.124	.124	.119	.114	.21	"	.120
" 11	.131	.130	.117	.123	.53	"	.125
" 12	.122	.125	.107	.118	1.83	"	.118
Block 13	.128	.118	.117	.139	3.27	N.S.	.126
" 14	.138	.134	.127	.124	1.12	"	.131
" 15	.144	.130	.126	.144	.88	"	.136
" 16	.133	.128	.141	.141	.82	"	.136

TABLE 22
MEAN "g" VALUES FOR ACCELERATION TRANSMITTED
TO THE HEAD 16 HZ EXPOSURES

DURATION GROUPING	SAMPLES				F-Ratio	Significance Level	Mean
	1st	2nd	3rd	4th			
16 Minute Mean	.786	.701	.714	-	.38	N.S.	.734
25 Minute Mean	.542	.503	.512	.558	.77	N.S.	.529
2.5 Hour Mean	.214	.200	.197	.190	2.73	N.S.	.200
Block 1	.219	.197	.191	.192	2.72	"	.200
" 2	.222	.212	.187	.179	1.74	"	.200
" 3	.197	.194	.200	.197	.13	"	.197
" 4	.208	.200	.191	.184	1.07	"	.196
" 5	.224	.197	.213	.201	.88	"	.209
4.0 Hour Mean	.177	.173	.168	.167	1.15	N.S.	.171
Block 1	.172	.167	.170	.159	.38	"	.167
" 2	.168	.171	.165	.159	.67	"	.166
" 3	.176	.158	.156	.162	1.12	"	.163
" 4	.165	.160	.172	.160	.63	"	.164
Block 5	.187	.181	.184	.177	.21	N.S.	.182
" 6	.181	.200	.181	.18	1.69	"	.186
" 7	.189	.153	.148	.146	1.65	"	.159
" 8	.176	.191	.169	.190	1.45	"	.182
8.0 Hour Mean	.111	.106	.099	.102	3.44	.05	.105
Block 1	.132	.104	.106	.115	2.68	N.S.	.114
" 2	.109	.107	.094	.100	1.18	"	.103
" 3	.109	.109	.089	.097	1.64	"	.101
" 4	.114	.114	.100	.102	2.22	"	.110
Block 5	.105	.106	.100	.109	.70	N.S.	.105
" 6	.108	.104	.104	.096	.76	"	.103
" 7	.107	.094	.086	.104	2.50	"	.097
" 8	.114	.114	.104	.098	1.43	"	.107
Block 9	.112	.109	.102	.118	.67	N.S.	.110
" 10	.096	.097	.098	.095	.14	"	.097
" 11	.102	.095	.094	.091	.61	"	.095
" 12	.111	.108	.097	.102	.33	"	.104
Block 13	.119	.103	.102	.091	1.86	N.S.	.104
" 14	.125	.117	.109	.102	2.82	"	.113
" 15	.104	.096	.093	.094	1.00	"	.097
" 16	.116	.108	.109	.120	1.21	"	.113

APPENDIX C
EXPERIMENTAL PROTOCOLS
(SHORT AND LONG TERM EXPOSURES)

PROTOCOL

Proposal by University of Dayton Research Institute (UDRI) to conduct non-hazardous human vibration experiments at AMRL under DHEW/NIOSH* Grant 1 RO1 OH-00479-01, using AMRL/BBV vibration machines, under project title

"EFFECTS OF VIBRATION ON HUMAN COMFORT AND PERFORMANCE"

(Series 1: short duration runs)

Purpose

The purpose of these experiments is systematically to evaluate the current limits of human vibration exposure established according to the "Fatigue-decreased Proficiency (FDP) Boundary" and the "Reduced Comfort (RC) Boundary" by the International Organization for Standardization for whole-body vibration (ISO 2631-1974).

Nature of Experiments

The experiments will involve a series of comparisons between human responses to low-frequency, whole-body, z-axis vibration with the same responses measured during no-vibration (control) periods of the same duration. The effects of duration (1, 16 and 25 minutes) and level (acceleration-amplitude of seat vibration) will be investigated concurrently at each of a series of frequencies in the range 2 to 32 Hz. The acceleration-amplitudes to be used will be limited by the current FDP Boundary specified in ISO 2631-1974, "Guide for the evaluation of human exposure to whole-body vibration".

The qualified and trained human volunteer subjects will be vibrated sinusoidally in the z-axis, seated on and restrained to a rigid seat in a standardized manner (see schematic diagram, Figure 1). The subjects' performance of various tasks will be measured during and immediately after vibration; certain physiological functions will be monitored using noninvasive procedures; and certain subjective reactions will be recorded.

Hypotheses to be tested

1. Vibration of short duration (up to 25 minutes) at ISO "FDP Boundary" levels will produce a measurable decrement in visual acuity in a minority of subjects but will not at any frequency significantly impair the performance of tests of central function (eg, attentional selectivity; vigilance). Furthermore, such vibration will not induce significant changes in the physiological state as indicated by heart rate, postural steadiness, kinesthetic function, or urinary constituents.

* National Institute for Occupational Safety and Health

2. Subjective response (stress severity and task difficulty rating) to vibration of short duration will be stronger (higher numerical ratings) at the FDP level than at the RC level at all frequencies and all durations.
3. Vibration of short duration at RC levels will have no measurable effect on any of the performance or physiological responses under study but will yield subjective ratings higher than those recorded in the no-vibration condition. Subjective ratings during vibration at any chosen level (FDP or RC) will not differ significantly with either duration or frequency of vibration.
4. Subjective ratings in response to vibration stress will be numerically higher (ie, adverse effects rated more strongly) in those subjects exhibiting extraversion on the IPAT 16PF personality test than among those exhibiting introversion on the same test.

Subjects

A panel of 36 subjects (from whom smaller groups will be drawn for particular experiments in the series) will be selected from University of Dayton student volunteers responding to on-Campus advertisements. The subjects will be qualified as medically fit to participate in vibration experiments; and their voluntary informed consent will be obtained in respect of all parts of the experimental program*. Current Air Force, AMRL, and University of Dayton regulations in this connection will be fully respected, as will pertinent DHEW/NIOSH rules.

Subject qualification will be based on a detailed medical and vibration exposure history, a physical examination and, in cases recommended by the examining physician, a radiological examination of the lumbosacral spine. Certain conditions (eg, recurrent spinal or urinary ailments; pregnancy; or other conditions at the discretion of the examining physician) will normally exclude applicants from selections as subjects.

The subjects will be reimbursed on an hourly basis for all times of attendance (including qualification and training, as well as experimentation) at the customary University rate.

Vibration Conditions

Z-axis, sinusoidal, whole-body vibration will be applied to all subjects, seated in a vehicle driving posture (Figure 1) through a rigid, tractor-type steel seat and metal footrests and handgrips; using, in succession, the Western Gear mechanical vibration machine in Building 93 at W-PAFB (for frequencies 2 to 8 Hz) and the C-5 electrodynamic or a similar vibration machine in Building 824 (for frequencies above 8 Hz), with the proviso that the machine in use at any time is currently man-rated for nonhazardous human experimentation. Note: not more than one vibration machine will be in active use by this UDRI project at any one time. Seat and footplate acceleration will be measured and monitored during all runs, using properly calibrated instrumentation. The following

* A copy of the subject's application form and Specimen Declaration of Consent is appended.

vibration conditions will be applied to the subjects:

Vibration frequencies: 2, 4, 8, 16, 32 Hz

Exposure durations: 1, 16, 25 minutes

Acceleration-amplitudes: determined by current ISO FDP and RC
Boundaries for the frequencies and durations
used but in no case to exceed the prevailing
FDP Boundary. Actual values to be applied
to the man by the seat are tabulated in Appendix
I for all experimental conditions.

Experimental measurements

The following categories of measurements will be made. The responses to be measured are identified in the following paragraphs.

1. Seat-head transmission of vibration (acceleration)
2. Performance
3. Physiological responses
4. Subjective responses

1. Seat-head Transmission of Vibration

Vibration transmitted to the head will be recorded and related to the reference z-axis seat acceleration measured at the subject's buttocks. Lightweight transducers will be individually fitted to the head in a firm but safe and comfortable manner, their functional axes being related to the anatomical co-ordinates of the head, in order to define head motion in the sagittal plane.

2. Performance

i) Visual Acuity

The Landolt broken ring test of visual resolution acuity will be presented during all experimental conditions; and a parallel lines test of visual vernier acuity will be presented during certain 1-minute runs. Subjects' responses will be verbal.

ii) One-dimensional Tracking Task (Footpedal)

A modified version of a simple tracking task previously developed by UDRI for AMRL will be performed during all 16- and 25-minute runs, except during the final minute, when visual acuity is being tested. In this task, the subject is required to use a right footpedal to maintain a pointer at a specified position on a boldface dial. The dial will not vibrate with the subject. The footpedal and left footrest will vibrate with the seat. The zero-displacement position of the footpedal will be at an angle of 60° from the baseplate. The pointer will be caused to move over the dial in a subjectively random manner, the subject being instructed to compensate for the motion. Cumulative error will be measured.

iii) Secondary Tasks

In separate experiments within the series, each of the following tests of central function will be presented at the same time as the tracking task:

(a) The Hockey Test of Attentional Selectivity

The subject faces a nonvibrated horizontal array of lights positioned at intervals of up to 80° on either side of a central point of regard. He is required to push a handgrip mounted button whenever one of the lights comes on, which they are programmed to do in a subjectively random manner with equal probability. Each light coming on will be extinguished automatically after 6 seconds if the subject fails to respond. Response time, false responses, and missed lights will be recorded, and the scores correlated with the angular distance of each light from the centerline. (Hockey, G R J, The effect of loud noise on attentional selectivity. Quart J exp Psychol, 22, 28-36. 1970.)

(b) The Wilkinson Auditory Vigilance Test*

The subject listens to a series of test tones presented against a background of white noise (80 dB SPL) through a headset (which is worn in all experimental runs). The normal tone lasts 500 ms and the tones are presented at 2-second intervals throughout the test. A constant, low (approximately 5 dB) signal/noise ratio is maintained. Approximately one tone in every forty-five, occurring at random intervals, is actually shorter (400 ms) than the standard tone. The subject's task is to respond to the short tones by pressing a button mounted on the handgrip. Response time, missed signals and false responses will be recorded.

Both the above tests are expected to be sensitive to duration of exposure and to vibration-induced difficulty in performing the primary task.

iv) Color Coding Task

In a modification of a traditional test of fatigue used in industrial psychology, the subject is presented with a chart of colored spots. Each primary color is given a code number which the subject learns. He must correctly identify each spot in sequence by its color code number. False responses and time to complete the chart are scored. The test will be presented at the end of each period of performing the tracking and secondary tasks.

* Wilkinson, R T, Methods for research on sleep deprivation and sleep function. Int Psychiat Clin, 7, 369-382. 1970.)

The medical qualification, selection, and training of subjects will be the responsibility of UDRI, as will all data collection and analysis. Because these experiments are proposed as nonhazardous, no on-site medical monitoring will be requested from AMRL. However, AMRL will be requested to provide the experimental team with initial instruction and qualification as operators of the two vibration machines to be used in these studies. The names of all UDRI qualified operators will be provided to AMRL/BBV. It is understood that the powering, proper mechanical and safety inspection and regular maintenance of the vibration machines in use at W-PAFB will remain the responsibility of AMRL.

Facilities

The experiments proposed in this protocol are to be conducted on the Western Gear vibration machine in Building 93, Area B, Wright-Patterson AFB, in the case of the low-frequency (2 to 8 Hz) series and on the C-5 (or similar) vibration machine to be made available in Building 824 for the higher frequencies (8 to 32 Hz). This proposal is made with the proviso that the machine in use by UDRI at any time is currently man-rated for nonhazardous human experimentation. It is understood that the vibration machines have each been provided with an acceleration sensor programmed to shut down the device automatically in the event of the preset maximum allowable seat acceleration (determined by the ISO FDP Boundary) being exceeded at any frequency of operation. It is understood, furthermore, that AMRL will provide power and maintain the vibration machines in proper running order during all duly scheduled periods of use by UDRI during this project. UDRI will keep a log of all runs made using the AMRL vibration machines: this log will be available for inspection by AMRL.

Apparatus and Equipment

All experimental and monitoring equipment other than the designated vibration machines will be provided on-site by UDRI. The subject's seat, adaptable for use on both vibration machines, has been designed and constructed by UDRI. It is illustrated diagrammatically in Figure 1: engineering drawings are to be made available to the AMRL Safety Committee, who will have an opportunity to inspect the seat and associated experimental apparatus before human runs are made.

The rigid unpadded, tractor-type seat is securely mounted on a base plate which also carries the footrests and handgrips, to be vibrated in phase with the seat (this will be established by direct measurement) (Figure 1). Subject to preliminary vibration tests using dummy loads, and to inspection and approval by the AMRL Safety Committee, the base plate carrying the seat will be properly mounted on whichever vibration machine is in use. The entire mass to be vibrated will be supported in such a manner that dynamic equilibrium and an equivalent load between subjects are maintained. Ballasting up to a total subject load of 250 lbs will be used to achieve the latter requirement. Electrically safe connections will be made to the subject's response buttons and footpedal mounted on the device.

The subject will wear a lap-belt provided with a tensioning device to restrain all subjects to the seat with a standard tension of 30 lbs. The subject will also wear a headset which will be used to present the Wilkinson Auditory Vigilance Task in appropriate runs, and 80 dB SPL of white masking noise in all runs. Monitoring head-mounted vibration transducers (accelerometers) and chest EKG electrodes will be fitted individually to each subject. No invasive physiological instrumentation is to be used. Urine samples will, however, be obtained for analysis before and after every run.

All visual displays and targets (including visual acuity test apparatus, Hockey test target lights, and the tracking task display) will be mounted on a non-vibrating display separate from the vibrating system. A removable, free-standing enclosure is to be provided by UDRI for this purpose. The safety of all electrical connections to the vibrating seat, and to equipment handled by or attached to the subject, will be subject to inspection by AMRL.

Schedule and Liaison with AMRL

Equipment vibration trials and subject selection and training are scheduled for the Fall of 1974. Vibration tests with human subjects are scheduled to take place on the Western Gear vibration machine in Building 93 beginning November 1, 1974.

Scheduling of experiments at AMRL has been and will continue to be arranged through the office of Col Dewey V Sturges, USAF, Chief, AMRL/BBV. Liaison concerning the progress of the work and presentation of data will also be maintained with Dr H E von Gierke, Chief, AMRL/BB, Joint Project Officer, as well as with NIOSH, Cincinnati, Ohio.

Preparation of Protocol

This Protocol has been prepared by Dr J C Guignard with the assistance of Miss B I Hunt and Mr G J Landrum at UDRI, and is submitted by Dr J C Guignard, Principal Investigator.

Date of this Protocol and Appendices

September 30, 1974 (Revised November 25, 1974).

Attch/

(J C Guignard)

APPENDIX I to PROTOCOL: EXPERIMENTAL CONDITIONS

(Guignard, J C, UDRI, 1974-09-30, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-01)

Z-axis seat acceleration levels (maximum g) as a function of vibration frequency and exposure time:

Frequency (Hz)	Exposure Time (Mins)	Reduced Comfort Boundary (ISO)	Fatigue-decreased Proficiency Bound- ary (ISO) *
2	1	0.130	0.408
4	1	0.091	0.286
8	1	0.091	0.286
16	1	0.182	0.571
32	1	0.363	1.142
2	16	0.097	0.306
4	16	0.068	0.216
8	16	0.068	0.216
16	16	0.138	0.433
32	16	0.274	0.867
2	25	0.080	0.255
4	25	0.058	0.184
8	25	0.058	0.184
16	25	0.115	0.362
32	25	0.229	0.724

Note: The vibration acceleration level will be zero during control runs at each duration (the subject will be seated on the vibration machine at rest.

APPENDIX II.A to PROTOCOL: EXPERIMENTAL CONDITIONS (16 & 25 MIN RUNS)

(Guignard, J C, UDRI, 1974-09-30, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-01)

Experimental conditions to be run on each vibration machine during 16 and 25 minute exposure experiments:

Condition	Western Gear Vibrator			C-5 Vibrator		
	Frequency (Hz)	Accel Level*	Duration (min)	Frequency (Hz)	Accel Level*	Duration (min)
1	2	RCB	16	8	RCB	16
2	2	FDPB	16	8	FDPB	16
3	2	RCB	25	8	RCB	25
4	2	FDPB	25	8	FDPB	25
5	4	RCB	16	16	RCB	16
6	4	FDPB	16	16	FDPB	16
7	4	RCB	25	16	RCB	25
8	4	FDPB	25	16	FDPB	25
9	8	RCB	16	32	RCB	16
10	8	FDPB	16	32	FDPB	16
11	8	RCB	25	32	RCB	25
12	8	FDPB	25	32	FDPB	25
13**	-	0	16	-	0	16
14**	-	0	25	-	0	25

* Actual values of RCB and FDPB are shown in Appendix I.

** Control (no-vibration) runs

APPENDIX II.B to PROTOCOL: ACTIVITIES DURING VIBRATION

(Guignard, J C, UDRI, 1974-09-30, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-01)

Schematic chart showing timing of performance and subjective tests during vibration and no-vibration (control) exposure periods (16 and 25 minute runs):

16-minute runs

ACTIVITY	TIME: 0	4	8	12	16	minutes
Vibration*						
Tracking						
Secondary Task**						
Visual Task***						--
Task Difficulty Rating						'
Stress Severity Rating						'

25-minute runs

ACTIVITY	TIME: 0	4	8	12	16	20	25 mins
Vibration*							
Tracking							
Secondary Task**							
Visual Task***							--
Task Difficulty Rating							'
Stress Severity Rating							'

* Except during no-vibration (control) exposures

** Hockey Attentional Selectivity or Wilkinson Auditory Vigilance

*** Visual Acuity or Color Coding

APPENDIX II.C to PROTOCOL: TYPICAL RUNNING PROTOCOL (16 & 25 MIN RUNS)

(Guignard, J C, UDRI, 1974-09-30, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 R01 OH-00479-01)

Timing of activities during pre- and post-vibration periods:

	TIME (mins)	ACTIVITY
P R E - V I B R A T I O N	-30	Subject reception formalities and briefing
	-26	Pre-vibration urine sample
	-24	Don headgear, electrodes
	-18	Group 1 tests*
	-10	Board vibration machine and make connections
	-06	Practice tracking and secondary task; any questions
	-04	Pre-vibration visual acuity
	-03	Group 2 tests**
	-01	Prepare to run
	00	RUN (16 or 25 minutes; vibration or control)
P O S T - V I B R A T I O N	+00	Group 2 tests**
	02	Disconnect and dismount
	03	Group 1 tests*
	11	Post-vibration urine sample
	13	Doff headgear, electrodes, etc
	17	Repeat Group 1 tests*
	25	Repeat Group 2 tests*
P	27	Debriefing

* Sway/tremor; kinesthetic tests; manual dexterity.

** Critical Flicker Fusion Frequency; dynamometer; vasomotor.

PROTOCOL

Proposal by University of Dayton Research Institute (UDRI) to conduct nonhazardous human vibration experiments at AMRL under DHEW/NIOSH* Grant 1 RO1 OH-00479-01, using AMRL/BBV vibration machines, under project title

"EFFECTS OF VIBRATION ON HUMAN COMFORT AND PERFORMANCE"
(Series 2: Long Duration Runs)

Purpose

The purpose of these experiments is systematically to evaluate the current limits of human vibration exposure established according to the "Fatigue-decreased Proficiency (FDP) Boundary" by the International Organization for Standardization for whole-body vibration (ISO 2631-1974).

Nature of Experiments

The experiments will involve a series of comparisons between human responses to low-frequency, whole-body, z-axis vibration with the same responses measured during no-vibration (control) periods of the same duration. The effects of duration, (2.5, 4.0 and 8.0 hours) and level (acceleration-amplitude of seat vibration) will be investigated concurrently at each of a series of frequencies in the range 2 to 32 Hz. The acceleration-amplitudes to be used will be limited by the current FDP Boundary specified in ISO 2631-1974, "Guide for the evaluation of human exposure to whole-body vibration".

The qualified and trained volunteer subjects will be vibrated sinusoidally in the z-axis, seated on and restrained to a rigid seat in a standardized manner (see schematic diagram, Figure 1). The subjects' performance of various tasks will be measured during and immediately after vibration; certain physiological functions will be monitored using noninvasive procedures; and certain subjective reactions will be recorded.

Hypotheses to be Tested

1. Vibration of long duration (up to 8 hours) at ISO "FDP Boundary" levels will produce a measurable decrement in visual acuity in a minority of subjects but will not at any frequency significantly impair the performance of tests of central function (eg, attentional selectivity; vigilance). Furthermore, such vibration will not induce significant changes in the physiological state as indicated by heart rate, postural steadiness, kinesthetic function, or urinary constituents.

* National Institute for Occupation Safety and Health

2. Vibration of long duration at FDP levels will have no measurable effect on any of the performance or physiological responses under study but will yield subjective ratings higher than those recorded in the no-vibration condition.
3. Subjective ratings in response to vibration stress will be numerically higher (ie, adverse effects rated more strongly) in those subjects exhibiting extraversion on the IPAT 16PF personality test than among those exhibiting introversion on the same test.

Subjects

A panel of 16 subject volunteers (from whom smaller groups will be drawn for particular experiments in the series) will be selected from University of Dayton students and off-duty community firemen. The subjects will be qualified as medically fit to participate in vibration experiments; and their voluntary informed consent will be obtained in respect of all parts of the experimental program*. Current Air Force, AMRL, and University of Dayton regulations in this connection will be fully respected, as will pertinent DHEW/NIOSH rules.

Subject qualification will be based on a detailed medical and vibration exposure history, a physical examination and, in cases recommended by the examining physician, a radiological examination of the lumbosacral spine. Certain conditions (eg, recurrent spinal or urinary ailments; pregnancy; or other conditions at the discretion of the examining physician) will normally exclude applicants from selections as subjects.

The subjects will be reimbursed on an hourly basis for all times of attendance (including qualification and training, as well as experimentation) at the customary University rate.

Vibration Conditions

Z-axis, sinusoidal, whole-body vibration will be applied to all subjects, seated in a vehicle driving posture (Figure 1) through a rigid, tractor-type steel seat and metal footrests and handgrips; using, in succession, the Western Gear mechanical vibration machine in Building 93 at W-PAFB (for frequencies 2 and 4 Hz) and the C-5 electrodynamic or a similar vibration machine in Building 824 (for frequencies above 8 Hz), with the proviso that the machine in use at any time is currently man-rated for nonhazardous human experimentation. Note: not more than one vibration machine will be in active use by this UDRI project at any one time. Seat and footplate acceleration will be measured and monitored during all runs, using properly calibrated instrumentation. The following vibration conditions will be applied to the subjects:

* A copy of the subject's application form and Specimen Declaration of Consent is appended.

Vibration frequencies: 2, 4, 8, 16, 32 Hz

Exposure durations: 2.5, 4.0 and 8.0 Hours

Acceleration-amplitudes: determined by current ISO Standard (2631-1974) for the frequencies and durations used but in no case to exceed the prevailing FDP Boundary. Actual values to be applied to the man by the seat are tabulated in Appendix I for all experimental conditions.

Experimental Measurements

The following categories of measurements will be made. The responses to be measured are identified in the following paragraphs.

1. Seat-head transmission of vibration (acceleration)
2. Performance
3. Physiological responses
4. Subjective responses

1. Seat-head Transmission of Vibration

Vibration transmitted to the head will be recorded and related to the reference z-axis seat acceleration measured at the subject's buttocks. Light-weight transducers will be individually fitted to the head in a firm but safe and comfortable manner, their functional axes being related to the anatomical co-ordinates of the head, in order to define head motion in the sagittal plane.

2. Performance

i) Visual Acuity

The Landolt broken ring test of visual resolution acuity will be presented during all experimental conditions; and a parallel lines test of visual vernier acuity will be presented during certain 30 minute blocks. Subjects' responses will be verbal. The test will be presented at the end of each period of performing the tracking and secondary tasks.

ii) One-dimensional Tracking Task (Footpedal)

A modified version of a simple tracking task previously developed by UDRI for AMRL will be performed for 24 minutes, (starting the fifth and ending the twenty-ninth), during each 30 minute testing block. In this task, the subject is required to use a right footpedal to maintain a pointer at a specified position on a boldface dial. The dial will not vibrate with the subject. The footpedal and left footrest will vibrate with the seat.

The zero-displacement position of the footpedal will be at an angle of 60° from the baseplate. The pointer will be caused to move over the dial in a subjectively random manner, the subject being instructed to compensate for the motion. Cumulative error will be measured.

iii) Secondary Tasks

In separate 30 minute experimental time blocks, each of the following tests of central function will be presented at the same time as the tracking task:

(a) The Hockey Test of Attentional Selectivity

The subject faces a nonvibrated horizontal array of lights positioned at intervals of up to 80° on either side of a central point of regard. He is required to push a handgrip mounted button whenever one of the lights comes on, which they are programmed to do in a subjectively random manner with equal probability. Each light coming on will be extinguished automatically after 6 seconds if the subject fails to respond. Response time, false responses, and missed lights will be recorded, and the scores correlated with the angular distance of each light from the centerline. (Hockey, G R J, The effect of loud noise on attentional selectivity. Quart J exp Psychol, 22, 28-36. 1970.)

(b) The Wilkinson Auditory Vigilance Test*

The subject listens to a series of test tones presented against a background of white noise (80 dB SPL) through a headset (which is worn in all experimental runs). The normal tone lasts 500 ms and the tones are presented at 2-second intervals throughout the test. A constant, low (approximately 5 dB) signal/noise ratio is maintained. Approximately one tone in every forty-five, occurring at random intervals, is actually shorter (400 ms) than the standard tone. The subject's task is to respond to the short tones by pressing a button mounted on the handgrip. Response time, missed signals and false responses will be recorded.

Both the above tests are expected to be sensitive to duration of exposure and to vibration-induced difficulty in performing the primary task.

iv) Color Coding Task

In a modification of a traditional test of fatigue used in industrial psychology, the subject is presented with a chart of colored spots. Each primary color is given a code number which the subject learns. He must correctly identify each spot in sequence by its color code number. False responses and time to complete the chart are scored. The test will be

* Wilkinson, R T, Methods for research on sleep deprivation and sleep function. Int Psychiat Clin, 7, 369-382. 1970)

presented at the end of certain 30 minute blocks of performing the tracking and secondary tasks.

3. Physiological Tests

A. Responses monitored during vibration and control runs

One channel of EKG will be monitored continuously throughout all runs (to yield heart rate and watch for ectopic beats).

B. Responses tested before and after vibration

- i) Urine (for blood and protein).
- ii) Postural steadiness (postural sway using force platform),
- iii) Peripheral neuromuscular function tests:
 - Purdue manual dexterity test.
 - Kinesthetic tests (2-point discrimination and forearm motion tests).
 - Strength of grip (dynamometer).
- iv) Forearm vasomotor reaction test (white reaction fading time).
- v) Critical flicker fusion frequency test (Lafayette).

4. Subjective Responses

i) Motion Severity and Task Difficulty Ratings

Modifications of a NASA-type 9-point subjective rating scale, previously used at AMRL to evaluate the severity of combined stress conditions including vibration (Grether, W F et al, Further study of combined heat, noise and vibration stress, Aerospace Med, 43, 641-645. 1972), will be presented to the subjects at standard intervals in all runs.

- ii) The 16PF Test (Raymond B Cattell & H W Eber, Institute for Personality and Ability Testing, 1967 edn) will be administered on a voluntary basis to all subjects. This reputable, one-hour, paper and pencil instrument measures several personality dimensions and the scores are presented in scale form. There are sixteen first order and seven second order derivatives determined but only one, namely, introversion-extroversion, is of interest in this series of experiments.

Note:

The confidentiality of all subjective, medical, and personal information given to the experimenters by the subjects will be preserved by the UDRI experimental team. Individual medical and other information will normally be kept securely at UDRI. Such records will not be transmitted to University of Dayton records; nor will they normally be made available

to DHEW/NIOSH, the Air Force, or any other person or agency. UDRI will however release particular medical records to AMRL upon special request in certain circumstances, namely, in the event of a subject sustaining an injury or illness arising during or attributable to experimental vibration exposure at AMRL.

Experimental Design

The responses of up to 16 subjects will be examined systematically during exposure to vibration at acceleration levels determined by the FDP Boundary at ISO-preferred values of duration in the range 2.5 to 8.0 hours and frequency in the range 2 to 32 Hz.

Groups of 8 subjects will be tested for 4, 5, or 9 hours (including pre- and post-vibration activities) on separate attendances. All subjects will be given a minimum of 4 hours training on the psychomotor performance tasks prior to the experimental program.

The runs made on the Western Gear and on the electrodynamic vibration machine respectively will be treated administratively and analytically as separate experiments. The Western Gear experiment will consist of 8 subjects exposed to 9 experimental conditions, namely, 2 frequencies (2 and 4 Hz) by 3 exposure times (2.5, 4.0 and 8 hours) and 3 no-vibration control conditions (one for each of the three durations). The electrodynamic vibration machine experiment will consist of 8 subjects exposed to 12 experimental conditions. The conditions are comprised of 3 frequencies (8, 16, and 32 Hz) by 3 exposure times (2.5, 4.0 and 8 hours) and 3 no-vibration control conditions. The treatments in each experiments will be presented to the subjects in a randomized block design. At least 24 hours will be allowed to elapse between any two exposures for any individual subject; and the subject exposures will incidentally be balanced for time of day.

The experimental conditions to be presented in the long duration series are summarized in Appendix I. Appendix II gives a schematic chart of the presentation of tests to the subjects during each 30 minute time block (vibration or control). Appendix III shows a typical subject running protocol for pre- and post-vibration psychophysiological testing.

Staffing

This series of experiments will be conducted entirely by UDRI personnel, under the direction of the Co-Principal Investigators, Dr J C Guignard, Adjunct Research Physiologist and Mr G J Landrum, Research Psychologist. The on-site experimental team will include Mr G J Landrum, who will be in day-to-day charge of the experiments and data collection, and assisted by Mr Robert E Reardon, Research Psychologist. Both will be qualified by AMRL as vibrator

operators. The advice of suitably qualified and experienced UDRI staff has been and will continue to be obtained in the design and fabrication of all experimental equipment to be vibrated with or applied to the subjects, in the experimental design, and in the collection and statistical analysis of data.

The medical qualification, selection, and training of subjects will be the responsibility of UDRI, as will all data collection and analysis. Because these experiments are proposed as nonhazardous, no on-site medical monitoring will be requested from AMRL. However, AMRL will be requested to provide the experimental team with initial instruction and qualification as operators of the two vibration machines to be used in these studies. The names of all UDRI qualified operators will be provided to AMRL/BBV. It is understood that the powering, proper mechanical and safety inspection and regular maintenance of the vibration machines in use at W-PAFB will remain the responsibility of AMRL.

Facilities

The experiments proposed in this protocol are to be conducted on the Western Gear vibration machine in Building 93, Area B, Wright-Patterson AFB, in the case of the low-frequency (2 and 4 Hz) series and on the C-5 (or similar) vibration machine to be made available in Building 824 for the higher frequencies (8 to 32 Hz). This proposal is made with the proviso that the machine in use by UDRI at any time is currently man-rated for nonhazardous human experimentation. It is understood that the vibration machines have each been provided with an acceleration sensor programmed to shut down the device automatically in the event of the preset maximum allowable seat acceleration (determined by the ISO FDP Boundary) being exceeded at any frequency of operation. It is understood, furthermore, that AMRL will provide power and maintain the vibration machines in proper running order during all duly scheduled periods of use by UDRI during this project. UDRI will keep a log of all runs made using the AMRL vibration machines: this log will be available for inspection by AMRL.

Apparatus and Equipment

All experimental and monitoring equipment other than the designated vibration machines will be provided on-site by UDRI. The subject's seat, adaptable for use on both vibration machines, has been designed and constructed by UDRI. It is illustrated diagrammatically in Figure 1: engineering drawings are to be made available to the AMRL Safety Committee, who will have an opportunity to inspect the seat and associated experimental apparatus before human runs are made.

The rigid unpadded, tractor-type seat is securely mounted on a base plate which also carries the footrests and handgrips, to be vibrated in phase with the seat (this will be established by direct measurement) (Figure 1). Subject to preliminary vibration tests using dummy loads, and to inspection and approval by the AMRL Safety Committee, the base plate carrying the seat will be properly mounted on whichever vibration machine is in use. The entire mass to be vibrated will be supported in such a manner that dynamic equilibrium and an equivalent load between subjects are maintained. Electrically safe connections will be made to the subject's response buttons and footpedal mounted on the device.

The subject will wear a lap-belt provided with a tensioning device to restrain all subjects to the seat with a standard tension of 30 lbs. The subject will also wear a headset which will be used to present the Wilkinson Auditory Vigilance Task in appropriate runs, and 80 dB SPL of white masking noise in all runs. Monitoring head-mounted vibration transducers (accelerometers) and chest EKG electrodes will be fitted individually to each subject. No invasive physiological instrumentation is to be used. Urine samples will, however, be obtained for analysis before and after every run.

All visual displays and targets (including visual acuity tests apparatus, Hockey test target lights, and the tracking task display) will be mounted on a nonvibrating display separate from the vibrating system. A removable, free-standing enclosure is to be provided by UDRI for this purpose. The safety of all electrical connections to the vibrating seat, and to equipment handled by or attached to the subject, will be subject to inspection by AMRL.

Schedule and Liaison with AMRL

Equipment vibration trials and subject selection and training are scheduled for the spring of 1975. Vibration tests with human subjects are scheduled to take place on the Western Gear vibration machine in Building 93 beginning 15 June 1975.

Scheduling of experiments at AMRL has been and will continue to be arranged through the office of Col Dewey V Sturges, USAF, Chief, AMRL/BBV. Liaison concerning the progress of the work and presentation of data will also be maintained with Dr H E von Gierke, Chief, AMRL/BB, Joint Project Officer, as well as with NIOSH, Cincinnati, Ohio.

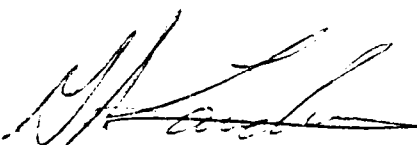
Preparation of Protocol

This Protocol has been prepared by Dr J C Guignard and Mr G J Landrum with the assistance of Mr R E Reardon at UDRI, and is submitted by Mr G J Landrum, Co-Principal Investigator.

Date of this Protocol and Appendices

20 May 1975.

Attach/



(G J Landrum)

APPENDIX I to PROTOCOL: EXPERIMENTAL CONDITIONS

(Guignard, J C, and Landrum, G J, UDRI, 1975-05-20, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-02)

Z-axis seat acceleration levels (maximum g) as a function of vibration frequency and exposure time:

Frequency (Hz)	Exposure Time (Hours)	Fatigue-decreased Proficiency Boundary (ISO)*
0	2.50	0.000
2	2.50	0.144
4	2.50	0.102
8	2.50	0.102
16	2.50	0.203
32	2.50	0.404
0	4.00	0.000
2	4.00	0.108
4	4.00	0.076
8	4.00	0.076
16	4.00	0.153
32	4.00	0.306
0	8.00	0.000
2	8.00	0.065
4	8.00	0.045
8	8.00	0.045
16	8.00	0.091
32	8.00	0.180

Note: The vibration acceleration level is zero for control runs at each duration (the subject will be seated on the vibration machine at rest).

* ISO 2631-1974

APPENDIX II to PROTOCOL: ACTIVITIES DURING VIBRATION

(Guignard, J C, and Landrum, G J, UDRI, 1975-05-20, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-02)

Schematic chart showing timing of performance and subjective tests during vibration and no-vibration (control) exposure blocks of 30 minute repeated time periods:

30-Minute Blocks

<u>Activity</u>	Time 0 _____ 30 minutes
Vibration*	_____
Tracking	_____
Secondary Task**	_____
Visual Task ***	—
Task Difficulty Rating	↑
Motion Severity Rating	↑

Note: Each of the 3 exposure durations will contain multiples of this 30 minute block, (2.5 hours = 5 blocks, 4 hours = 8 blocks, and 8 hours = 16 blocks).

* Except during no-vibration (control) exposures

** Hockey Attentional Selectivity or Wilkinson Auditory Vigilance

*** Visual Acuity or Color Coding

APPENDIX III to PROTOCOL: PRE- AND POST-VIBRATION TESTING

(Guignard, J C, and Landrum, G J, UDRI, 1975-05-20, "Effects of Vibration on Human Comfort and Performance". DHEW/NIOSH Grant 1 RO1 OH-00479-02)

Timing of activities during pre- and post-vibration periods:

Pre-Vibration

<u>Time</u>	<u>Activity</u>
-30	Subject reception and briefing
-26	Electrode placement
-24	Urine Sample
-18	Sway platform
-15	Kinesthetic Test
-12	Manual Dexterity Test
-10	Board Vibration Machine and make connections
-06	Critical Flicker Fusion Test
-04	Vasomotor Test
-02	Dynamometer Test
-01	Don headset and mouthpiece

Post-Vibration

<u>Time</u>	<u>Activity</u>
00	Critical Flicker Fusion Test
02	Vasomotor Test
04	Dynamometer Test
05	Disconnect and Dismount Vibration Machine
06	Sway platform
09	Kinesthetic Test
12	Manual Dexterity Test
15	Urine sample and Remove Electrodes
18	Debriefing

Key

- A. seat fixed to base
(vibrated platform)
- B. midline column carrying
bicornuate handgrips.
Distance AB is adjustable
to fixed settings
- C. Left and right footrests
(right is pedal for the
tracking task). Dist-
ance AC is adjustable
to fixed settings

NOT TO SCALE

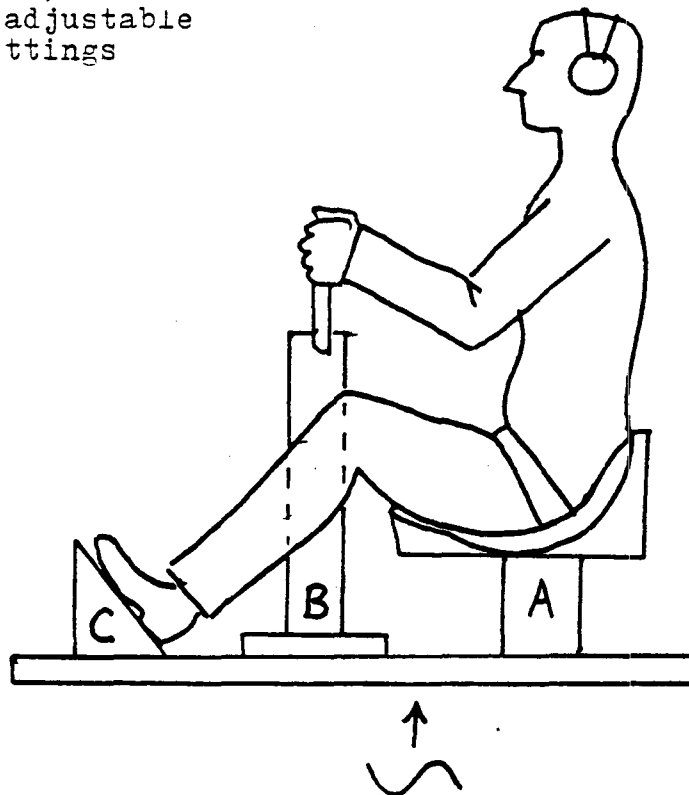


Figure 1. Schematic diagram showing subjects' riding position for UDRI vibration experiments (lateral view)

APPENDIX D
VIBRATION PANEL SUBJECT'S APPLICATION

CONFIDENTIAL

SUBJECT NO. ____/V

UNIVERSITY OF DAYTON RESEARCH INSTITUTE
Dayton, Ohio 45469

Human Vibration Experiment UDRI (NIOSH)-5-ROI-OH-00479-02
"EFFECTS OF VIBRATION ON HUMAN COMFORT AND PERFORMANCE"

APPLICATION * FOR SELECTION AS A MEMBER OF
THE UDRI VIBRATION SUBJECT PANEL

Please read the following Description of the Experiment carefully before filling out this application in full. Your application, and any other personal information which you provide, will be treated as confidential by the Experimenters.

DESCRIPTION OF THE EXPERIMENT

The Experiment is designed to measure psychological and physiological reactions to whole-body mechanical vibration of the kind which you might experience while driving a working vehicle such as a truck or a farm tractor. Its purpose is to provide data useful to the possible revision of International Standard ISO 2631-1974 "Guide for the evaluation of human exposure to whole-body vibration". As a qualified (physically fit) subject, you will be asked to attend on a series of occasions for 2 to 10 hours on each occasion. During each attendance (minimum: 11), there will be a series of simple tests of your physiological reactions, your subjective (personal) impressions, and your skill at performing simple tasks. You will be given preliminary training on the tasks.

While performing the tasks, you will be seated on a tractor type seat, firmly mounted on a vibration machine which we use to apply vibration to your seat and footrests in the vertical direction (up and down). While in the seat, you will wear a lapbelt, a headset (used to provide noise and signals used in one of the tasks), and some external instrumentation used to record your heartbeat and the amount of vibration transmitted to your head from the seat. For the latter purpose you will be fitted individually, by a dentist at our expense, with a small plastic dental clip-on device resembling a mouthguard. The experiment will be conducted at Wright-Patterson Air Force Base, Area B. The Experimenters will be members of the UDRI research staff.

Payment

Payment will be made at the rate of \$3.25 per hour of your time plus bonus money for reliable participation during testing. Payment will be made for your time spent on qualifying medical examinations (whether or not you qualify) as well as for training periods and experimental time. One hour's (\$3.25) additional payment will also be allowed for each round trip to WPAFB.

*Revised form, May 1975

Vibration Conditions

On each occasion that you attend, you will carry out the same kinds of tests but will undergo a different condition of vibration. The frequencies of vibration (number of cycles of motion per second, cps) will vary, from 2cps (resembling the jogging of a trotting horse) to 32 cps (resembling the vibration of a motor at speed). The length of time over which you will experience vibration will vary from 16 minutes to 8 hours. The intensity (acceleration) of the vibration will vary with the frequency and the time of exposure, but on no occasion will it exceed one half of the value permitted by the Exposure Limit set by the International Organization for Standardization (ISO 2631-1974) for human exposure to the same whole-body vibration on a daily basis. The intensity will be comparable with the motion you might experience driving a working vehicle (eg, tractor, truck). You will be asked not to engage in certain activities (eg, wild parties, drinking, violent recreations) less than 24 hours before experimentation.

Risks of Vibration Exposure

All the vibration exposures to be used in our experiments are deemed to be nonhazardous according to the current International Standard (ISO 2631-1974) on human exposure to whole-body vibration; and the exposures have been approved as nonhazardous by the University of Dayton Committee on the Protection of Human Subjects; by the National Institute of Occupational Safety and Health; and by the Human Research Review Committee of the Aerospace Medical Research Laboratory at Wright-Patterson AFB. The levels of vibration to be used are frequently exceeded in working vehicles and some form of public transportation. However, you should be aware that exposure to higher levels of vibration, particularly if prolonged or repeated on daily basis, may aggravate certain conditions in susceptible individuals. Such conditions include recurrent back trouble, urinary (including kidney) ailments, hemorrhoids, and stomach or duodenal ulcers. (Women applicants should also be aware that strong vibration may in some circumstances have a deleterious effect on the course of an existing pregnancy.) For these reasons, we require all applicants to give details of their medical history and to undergo examination by a physician; and we reserve the right not to accept as a vibration subject any applicant deemed unfit for medical reasons.

Tests

During vibration (and some control periods without vibration), we shall test your sharpness of vision (distant eyesight), your ability to keep steady control of a footpedal resembling an accelerator, your ability to react quickly and accurately to light signals. In some experiments, we may also test your skill at recognizing sounds heard against a background noise. We shall also ask you at intervals to rate subjectively your personal impressions of the vibration and its effect on your task, using simple numbered scales.

Before and after each period of vibration, we shall carry out a series of quick and simple tests of your muscular co-ordination and related physiological functions. None of these tests are in any way difficult, uncomfortable, or unpleasant to perform. We shall also ask you to provide a urine specimen for analysis before and after every vibration exposure: we shall provide clean, labelled containers and a private place for your use for this purpose.

Further details of any of the tests or procedures, and of the nature and purpose of the experiment, will be provided by the Experimenters on request (UD extension 3216. Ask for Mr. Landrum or Mr. Reardon).

Medical Fitness

It is necessary that the Experimenters insure that you are physically fit to undergo moderate vibration exposure and to carry out all the tests in the series. For this reason, we have to ask you to submit to a qualifying physical examination by a licensed physician.

The qualifying physical examination may, at the discretion of the examining physician, be supported by an X-ray examination of your lower spine. Qualifying examinations carried out by the Physician will be entirely at our expense; indeed, we shall reimburse you at the customary University rate for your time spent on it.

Important Note: Any and all medical records and personal information about you, including the results of the physical, will be kept as confidential by the Experimenters at UDRI. We shall not divulge personal information or the results of individual psychological tests to the University of Dayton administration or to any other person or agency without your consent. If you so desire, however, we are willing to provide your own doctor with the result of any physical examination of you carried out by our own examining physician. In exceptional circumstances (eg, illness developing during an experimental run), it may be necessary for medical records to be made available for inspection by an Air Force physician at the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, in whose facilities the experiments are to be conducted.

Optional Personality Test

You may also be asked to carry out a simple, standard personality test, which we sometimes use to interpret the results of the subjective ratings of vibration exposure. However, the personality test will be conducted on an entirely voluntary basis: you may refuse to take it without prejudice to your application to be a member of the Vibration Subject Panel. If you do take the personality test (as we hope you will), the results will again be treated as entirely confidential between yourself and the Experimenters. Individual subjects will not be identifiable from published results of the experiments. In no circumstances will the results of personality tests be divulged to the University of Dayton, the Air Force, or any other agency.

The Experimenters and Location

This project is funded by a grant (#1 RO1 OH-00479-01) from the National Institute of Occupational Safety and Health (NIOSH), US Department of Health, Education and Welfare to the Co-Principal Investigators at UDRI; Dr. J.C. Guignard, Adjunct Research Physiologist and Mr. G.J. Landrum, Research Psychologist. The experimentation will be conducted by Mr. G.J. Landrum and Mr. R.E. Reardon, Research Psychologist (UDRI 229-3216). The vibration experiments will be carried out at Wright-Patterson Air Force Base, Area B, where the USAF Aerospace Medical Research Laboratory is making man-rated vibration machines available for our use. Apart from providing these machines for use by UDRI under an inter-agency agreement with NIOSH, the Air Force will play no part in the direction or conduct of the experiments.

Scheduling of your attendances, and credentials to enter the Base, as well as reimbursement for all time given by you to this project (on an hourly basis) will be organized by Mr. Landrum and Mr. Reardon. The qualifying physical examination will be conducted at Wright State University by a physician, Chandler A. Phillips, M.D. Appointments will be arranged by Mr. Landrum.

Training and Experimental Runs

If selected as a member of the Vibrational Subject Panel, you will be asked to attend for a minimum of 4 paid hours training on the tasks before undergoing vibration experimentation at regular intervals (depending on your preferred schedule) during the period of June 1975 through April 1976.

Application

Please complete the following application only if you consider yourself to be in normal health (ie, fit enough to do a normal day's work, to use public transportation with assistance, and to take part in athletics or other active recreations). The Experimenters regret that we cannot accept applications from anybody who requires glasses or contact lenses for distance vision, anybody with a severe hearing loss in one or both ears, anybody who has undergone major surgery within the past 6 months or oral surgery within the past 3 months, or anybody who wears a removable denture. Applicants may also be excluded by other conditions at the discretion of the examining Physician.

IMPORTANT NOTE: You must be over 18 years of age to volunteer.

*It is most important to the success of these experiments that subjects, once selected, make every effort to complete the series, so that runs are not wasted. Continued participation is of course entirely voluntary but we do hope that, having started the series, subjects will not drop out unnecessarily.

Please reply to all questions in the Application (Part II) and sign Declaration 1 (on Page 2-4) before reading and signing Declaration 2 (Part III). Your signature in Part III should be witnessed.

CONFIDENTIAL

APPLICATION FOR QUALIFICATION AS A
MEMBER OF THE UDRI VIBRATION SUBJECT PANEL*

1. NAME (Mr) (Mrs) (Miss) (Ms) ()* _____ (Last) *If other title used, state if M or F. _____ (First) (Middle) 2. DATE OF BIRTH _____ (Mo) (Day) (Year) 3. Local or Campus ADDRESS _____ _____ Phone _____ 4. Height ____ft. ____in. Weight _____lbs. 5. Are you left or right-handed? _____ 6. Home Address (if not as above) _____ _____ Zip _____ Phone (____) _____ 7. UD Student? Check if "Yes" () Other University Student? () _____ Class _____ Div _____ Major _____ (College) 8. Check if NOT University Student () and complete Section 8(a and b). (a) Employer (enter "Self" or "Not employed" if appropriate) _____ _____ _____ Worktime Phone _____ (b) Position or Job Description _____ 9. US Citizen? (YES/NO) (If "No", please state citizenship and resident status) _____ 10. Person to contact in emergency: Name _____ Phone () _____ Address _____ Zip _____ Relationship (eg, spouse, parent, friend, employer) _____ * Student applicants omit question 8. Male applicants omit question 12(a). All applicants please <u>circle the appropriate word</u> in YES/NO questions.	<u>OFFICE USE ONLY</u> Application received _____ Audiogram _____ Res. _____ Physical _____ 19 _____ Result _____ Doctor _____ X-ray _____ 19 _____ Result _____ VSP Qualified: YES/NO Subject No. _____ Notes _____ _____ _____
--	---

MEDICAL HISTORY (CONFIDENTIAL)

11. Are you presently in good health? (YES/NO) (If "No" please explain briefly: _____)
12. Do you ever suffer from any of the following (circle if appropriate)? Back-ache; Severe or Persistent Headache; Fainting or Temporary Loss of Consciousness; Giddiness; Tremor (shaking) of head or limbs; Convulsions (Seizures); Asthma or troublesome Chest Ailments; Breathlessness; Heart Trouble; Gastric (stomach) or other Digestive Trouble; Female (Pelvic or Breast) Trouble; Hemorrhoids (Piles); Kidney Trouble; Skin Troubles; Nose-bleeds; Eye Trouble (eg, poor or changing vision); Ear Trouble (eg, poor or decreased hearing; earache; discharge from ears); Bad or missing Teeth; Any Other Conditions (YES/NO) (If "Yes", please give details):

- 12(a) Women Applicants (CONFIDENTIAL)
Are you pregnant? YES/NO. If "Yes" please estimate when due _____ 19____. Have you recently (last 3 months) had a pregnancy terminated? YES/NO. If "Yes" please give date _____ and stage _____ of termination.
13. Are you at present under medical treatment of any kind (eg, medication; dressings; physiotherapy; appliances (eg, trusses; braces); psychotherapy)? (YES/NO) If "Yes", please give particulars: _____
- 13(a) If "Yes", may we refer to your doctor or therapist? (YES/NO). If "Yes", please give his/her name and address: _____ Phone () _____
14. Do you wear glasses/contact lenses (circle if appropriate)? (YES/NO)
If "Yes", are they for distance/reading/both/other purpose: _____ (circle)?
15. Do you wear a denture? (YES/NO). If "Yes", please describe, stating whether it is fixed or removable: _____

16. Do you carry a cardiac pacemaker or any other kind of artificial internal device (including indwelling contraceptive devices) or prosthesis? (YES/NO). If "Yes", please give details: _____
17. Have you ever undergone surgery or suffered from a serious illness (ie, requiring hospitalization or a doctor's care at home)? (YES/NO). If "Yes", please give details, including dates and duration of treatment, and Hospital or MD's name and address _____
18. Have you ever been seriously injured in a street, sport, home, work, or other accident (ie, necessitating hospitalization or a doctor's treatment)? (YES/NO). If "Yes", please give details and dates, and say what (if any) residual disability the accident may have caused: _____
19. Have you been involved in any street, sport, home, work, or other accident within the past 6 months? (YES/NO). If "Yes", please give details: _____
20. Do you have any allergies (unusual sensitivity to certain foods, medications, physical agents, etc)? (YES/NO). If "Yes", please describe, stating the nature of your reaction(s): _____
21. Are you receiving a military or any other kind of disability allowance or pension? (YES/NO). If "Yes", please explain: _____
22. Have you ever been denied life/health insurance? (YES/NO). If "Yes", please give date and reason (if you have never applied for insurance, check here) _____

DECLARATION 1

I have replied to all the foregoing questions to the best of my knowledge and belief. I understand that knowingly failing to reveal relevant matters concerning my medical history and present state of health may invalidate my application and selection as a subject.

Signed _____

Date _____

SUPPLEMENTARY HISTORY (VIBRATION AND NOISE EXPOSURE)

23. Are you (or have you been) engaged in any job (for yourself or for another employer) involving exposure to vibration and/or noise (eg, construction work; heavy industry; tractor driving; truck driving; power mowing)?
(YES/NO). If "Yes", please give details of job(s): (If "none" so state):

(a) In present calendar year (19_). Type of Work: _____
Approximate hours per day _____ days per month _____
how many months _____. Was noise or vibration the main
feature? _____

What effect (if any) did the noise/vibration have on you (if "none", so state):

(b) In previous calendar year (19_). Type of Work: _____
Approximate hours per day _____ days per month _____
how many months _____. Was noise or vibration the main
feature? _____

What effect (if any) did the noise/vibration have on you (if "none", so state):

(c) In year(s) 19_ - ____: Type of work _____
Approximate hours per day _____ days per month _____
how many months _____. Was noise or vibration the main
feature? _____

What effect (if any) did the noise/vibration have on you (if "none", so state):

24. Do you engage (or have you engaged) in any recreations involving vibration and/or noise (eg, motorcycling; drag-racing; snowmobiling; power boating; water-skiing; powered handcrafts; riding lawn-mowers other than as a paid employment; horseback-riding; shooting; listening to loud music)? (YES/NO)
If "Yes", please state up to 3 main activities and estimate number of hours so spent:
- (a) Activity (1) _____ Hours in past week _____ month _____, year _____, 5 years _____. Did the vibration/noise have any effect on you? _____.
- (b) Activity (2) _____ Hours in past week _____ month _____, year _____, 5 years _____. Did the vibration/noise have any effect on you? _____.
- (c) Activity (3) _____ Hours in past week _____ month _____, year _____, 5 years _____. Did the vibration/noise have any effect on you? _____.
25. What kind(s) of mechanical transportation do you regularly or most frequently use (eg, car, bus, motorcycle, etc.)?
To get to and from work each day _____ Approximately _____ miles.
For other local travel each week _____ Approximately _____ miles.
(Vehicle Type)
(*Enter round trip mileage.)
Occasional/Regular long journeys (eg, on weekends; holidays) _____
Approximately _____ miles per trip.
26. How many miles per year do you reckon you travel by the following means (if none, enter "0")? (Estimate average over past 3 years.)
Automobile _____ Pickup truck* _____ Heavy truck _____
Bus/coach _____ Train _____ Motorcycle _____.
27. How many hours per year do you reckon you travel by the following means (if none, enter "0")? Jet airliner _____ Prop airliner _____
Light aircraft _____. Unusual means (eg, power boats, ships, helicopters, snowcraft): (Please state type(s) and estimate hours/year)
Type: _____ hrs/yr. Type: _____ hrs/yr.

* or van/camper

28. Do you ever suffer from motion sickness in any of the above vehicles?
(YES/NO). If "Yes", please identify type(s) of vehicle: _____

Are you made sick always, usually, frequently, occasionally, rarely
(circle one)?
- 28a. Do you ever notice after-effects of vehicle riding? (YES/NO). If "Yes",
please describe: _____

SUBJECT SELECTION PROCEDURES

29. Are you willing to submit to a physical examination (similar to a flight physical examination given routinely to civil aircrew) to determine your fitness to be a member of the Vibration Subject Panel? (YES/NO).
- 29a. Are you willing to have a dental impression made of your upper teeth (at our expense) for the purpose of fitting you individually with a lightweight dental plastic instrumentation mount (to be worn while you are undergoing vibration)? (YES/NO)
30. Are you willing to have an X-ray examination of your lower spine if such an examination is recommended by the examining Physician (the X-ray would be paid for by us and you would be reimbursed for your time spent attending for the examination)? (YES/NO)
31. Are you willing to take a personality test (a reputable paper-and-pencil test widely used in clinical psychology)? Note: this is entirely optional and is not a requirement for selection as a member of the Vibration Subject Panel. The results of the test will in all cases be kept entirely confidential between you and the Experimenters and will not be otherwise identifiable. (YES/NO)
32. Are you willing to avoid undue vibration exposure (including travel in rough-riding vehicles; motorcycling; violent sports activities) for at least 24 hours before each experimental test period? (YES/NO)

33. Are you willing to abstain from alcohol and other drugs for at least 24 hours before each experimental test period? (YES / NO)
34. Are you willing to provide specimens of your urine as and when requested by the Experimenters on experimental test days? (YES / NO)
35. I shall use the following type(s) of transportation to get to the laboratory at Wright-Patterson Air Force Base: _____



UNIVERSITY OF DAYTON
DAYTON, OHIO 45409

RESEARCH INSTITUTE

DECLARATION 2*

DECLARATION OF VOLUNTARY INFORMED CONSENT**

Print
name
in
full

I, _____ being over 18 years of age, hereby volunteer to participate as a member of the UDRI Vibration Subject Panel in experiments on "The Effects of Vibration on Human Comfort and Performance", the said experiments to be conducted by the University of Dayton Research Institute on man-carrying vibration machines at Wright-Patterson Air Force Base, Ohio during the period December 1, 1974 to _____ 19 _____. I understand that the purpose of the experiments is to obtain data useful to the possible revision of International Standard ISO 2631-1974, "Guide for the Evaluation of Human Exposure to Whole-Body Vibration".

Print
name
in
full

- 2 I have read Part I (Description of the Experiment") and completed Part II of the Application for selection to the UDRI Vibration Subject Panel. The nature of the experiments, their purpose, and the possible adverse and beneficial consequences of the experiments, have been explained to me to my satisfaction by:

(Name of Experimenter) _____,

(Position of Experimenter) _____,

of the University of Dayton Research Institute, whose signature appears hereunder

_____ (Signature of Experimenter)

_____ (Date)

- 3 This Consent is voluntary and is given in circumstances in which I can exercise free power of choice. I understand that I may at any time revoke this Consent and withdraw from the Experiment without prejudice. I further understand that the Experimenters or a Licensed Physician may terminate the experiment at any time at his, her, or their discretion, irrespective of my continued Consent.

*This portion of your Application is exempt from treatment as confidential.

**Revised form, November 1974.

DECLARATION 2*

Page 2

- 4 I understand that my selection and use as a subject in these experiments is dependent upon my qualification as medically fit to be a member of the UDRI Vibration Subject Panel. In order to establish fitness, I have consented to examination by a Licensed Physician appointed by the Experimenters.
- 5 I understand that, before any participation by me as an experimental subject, I must inform the Experimenters of any change in my medical status; and that this information must include any medications I may have taken and any medical or dental care or treatment received since my last examination or since my last use as an experimental subject.
- 6 I understand that I shall not be individually identifiable from any reports or scientific data published or released by the Experimenters; and that all personal records and information derived from me in the course of this project (including my above mentioned application and physical examination) will be properly treated as confidential by the Experimenters and will not be disclosed to any other person or agency without my written release except as required by law. I understand that the Experimenters may reasonably be required to disclose specified medical records to a physician representing the Aerospace Medical Research Laboratory in which the experiments are to be conducted.
- 7 If selected for use as an experimental subject, I undertake to make every endeavor to comply with the instructions and keep the appointments given to me by the Experimenters, subject only to my right to revoke my Consent declared above.

(Signature of Volunteer)
(Date)
(Signature of Witness)
(Date)

DECLARATION 3*

DECLARATION OF VOLUNTARY INFORMED CONSENT

I, _____ as a member of the
UDRI Vibration Subject Panel, having understood and signed the Voluntary
Consent Agreement Declaration 2 accept this revision pertaining to Clause
6 and question 31 of the Subject Selection Procedure:

I understand that I shall not be individually identifiable from
any reports or scientific data published or released by the
Experimenters; and that all personal records and information
derived from me in the course of this project will be properly
treated as Confidential by the Experimenters, (Experimenters
here including former UDRI employee, Bonnie I. Hunt, now
using this information in conjunction with completion of her
Ph. D. program at Texas A&M University), and will not be
disclosed to any other person or agency without my written
release except as required by law.

(Signature of Volunteer)
(Date)
(Signature of Witness)
(Date)

*This portion of your Application is exempt from treatment as confidential.

APPENDIX E
VIBRATION SUBJECT'S INSTRUCTIONS

UNIVERSITY OF DAYTON RESEARCH INSTITUTE

VIBRATION SUBJECT'S INSTRUCTIONS

Human Vibration Experiment UDRI(NIOSH)-1-RO1-OH-00479-01

"Effects of Vibration on Human Comfort and Performance"

Series 1. Short Duration Experiments

Run durations 16 and 25 minute(s)

Location: Building _____, Area B, WPAFB Telephone -

On-Campus Inquiries:

Run Scheduling: 3216

General Inquiries: 3216

GENERAL INSTRUCTIONS*

(16 and 25 Minute Runs)

Purpose

This experiment is one in a series designed to evaluate systematically the current human vibration exposure limits established by the International Organization for Standardization for whole-body vibration affecting man (ISO 2631-1974). The vibration exposures are determined according to the "Fatigue-Decreased Proficiency (FDP) Boundary" and "Reduced Comfort (RC) Boundary" defined in that International Standard.

Nature of Experiment

The experiment will involve a measurement of your performance on a group of psychological and physiological tasks. While performing the tasks, you will be seated on a tractor type seat, firmly mounted on a vibration machine which we use to apply vibration to your seat and footrests in the vertical direction (up and down). You will wear a lapbelt, a headset (used to provide noise and signals used in one of the tasks), and some external instrumentation, used to record your heart beat (stick-on electrodes) and the amount of vibration transmitted to your head from the seat (miniature lightweight accelerometers mounted on an individually molded mouthpiece and a headstrap).

You are required to attend for experimentation on a minimum of 8 occasions for 2 hours. The first two attendances will be used solely for familiarization with the experimental procedure and training on the performance tests. The remaining 6 attendances are experimental periods in which the vibration conditions will be presented in a random order.

Vibration Conditions

On each of the 6 experimental periods, you will carry out the same test procedure but will undergo a different condition of vibration. The frequency of vibration (number of cycles per second) will vary, from 2 cps (resembling a trotting horse) to 8 cps (resembling the vibration of an idling diesel engine). The length of time over which you will experience vibration will be either 16 minutes or 25 minutes. The acceleration (intensity) of the vibration is determined by exposure time (16 or 25 minutes) and frequency (2, 4, or 8 cps), but on no occasion will it exceed one half the value permitted by the Exposure Limit set by ISO for human daily vibration exposure. The intensity will be comparable with motion experienced while driving a working vehicle (eg, tractor, truck). In two of the experimental periods (control), one of 16 minutes and one of 25 minutes you will perform the tasks in the same manner but the seat will not be vibrated.

*Please study these instructions carefully. Do not hesitate to ask for a fuller explanation if any point is not entirely clear to you.

You will be scheduled so that you do not undergo vibration testing any more than once in every 24 hours. Also, you are requested NOT to take part in activities such as violent recreation, wild parties or drinking less than 24 hours before training or experimental periods.

Tests

Before and after each vibration period, you will perform a series of quick and simple tests. All tests will always be presented in the same order regardless of the vibration exposure level or duration. The testing schedule for Pre-Vibration and Post-Vibration periods is given in Exhibit B. Particular tests are explained further in their respective Exhibits.

During the vibration and two control experimental periods, your performance of additional tasks will be measured. The major part of your time will be spent working on a combination of two tasks, namely "Tracking" (primary task, Exhibit M) and a secondary task. Near the end of the run, your sharpness of vision will be tested. You will also subjectively rate your personal impressions of the vibration conditions in which you are working, and the task difficulty. The testing schedule is given in Exhibit C. Each performance task is explained in detail in following Exhibits.

Optional Personality Test

You may also be asked to carry out a simple, standard personality test, which we sometimes use to interpret the results of the subjective ratings of vibration exposure. However, the personality test will be conducted on an entirely voluntary basis: you may refuse to take it without prejudice to your application for membership on the Vibration Subject Panel. If you do take the personality test (as we hope you will), the results will again be treated as entirely confidential between yourself and the Experimenters. Individual subjects will not be identifiable from published results of the experiments.

The Experimenters and Location

This project is funded by a grant (#1 RO1 OH-00479-01) from the National Institute of Occupational Safety and Health (NIOSH), US Department of Health, Education and Welfare to the Co-Principal Investigators at UDRI; Dr. J. C. Guignard, Adjunct Research Physiologist and Mr. G. J. Landrum, Research Psychologist. The experimentation will be conducted by Mr. G. J. Landrum and Mr. R. E. Reardon, Research Psychologist (UDRI 229-3216). The vibration experiments will be carried out at Wright-Patterson Air Force Base, Area B, where the USAF Aerospace Medical Research Laboratory is making man-rated vibration machines available for our use. Apart from providing these machines for use by UDRI under an inter-agency agreement with NIOSH, the Air Force will play no part in the direction or conduct of the experiments.

Scheduling of your attendances, and credentials to enter the Base, as well as reimbursement for all time given by you to this project (on an hourly basis) will be organized by Mr. Landrum and Mr. Reardon. The qualifying

physical examination will be conducted at Wright State University by a physician, Chandler A. Phillips, M.D. Appointments will be arranged by Mr. Landrum.

Do's and Don'ts (All Runs)

(a) On the day (ie, at least 24 hours)/before any scheduled run:

PLEASE DO NOT

- (1) Engage in violent, noisy, or excessively active pursuits or recreations (eg, motorcycling, powerboating, snowmobiling, horseback riding, skiing, karate. Note: if you are a footballer or other UD team game player who must practice regularly please advise us regarding your schedule or have your Coach discuss it with us.)
- (2) Indulge in alcohol, pot, or other drugs.
- (3) Attend concerts, parties, discos (or listen to home stereo) where the sound level is likely to be excessive (ie, loud enough to affect your hearing or make your ears ring afterwards or to make it necessary to shout to converse face-to-face during the music).

PLEASE DO

- (1) Inform the Experimenters (UD Ext. 3216) or the Student Coordinator (Ext. 4129) if you have a cold or any other illness (including toothache) or if for any other reason it is necessary for you to reschedule your run.
- (2) Remember to tell the Experimenters prior to each run if you have undergone any changes in your medical status or are taking any medication.

(b) On the day of any scheduled run:

PLEASE DO NOT

- (1) Be late.
- (2) Smoke in the experiment room.
- (3) Attend if you are unwell (you can always reschedule your run if you do not feel well).

PLEASE DO

- (1) Wear reasonably "sensible" everyday clothing and footwear. Avoid heavy boots and shoes with high heels or high platform soles. Avoid trailing garments. Avoid stiff and heavy garments (eg, combat jackets with bulging pockets). Women subjects should wear jeans or slacks and whatever breast support they normally feel most comfortable with when riding in vehicles. Men and women subjects with long hair should bring a lightweight clasp or tie to hold the hair behind the neck.

- (2) Try to wear the same (or similar) footwear and clothing on each attendance. This is important because these items can influence your response to vibration.
- (3) Let us know as early in the day as possible (229-3216 or 254-2181) if for any reason you have to cancel your scheduled attendance.

(c) At any time:

PLEASE DO NOT

Discuss with other subjects (or potential subjects) your performance of any of the tasks, the numbers which you or they have given in the subjective rating tests, or the answers you may have given in the personality test. We make this request especially to avoid the possibility of one subject accidentally influencing the results of another.

IMPORTANT

Your scores in all tasks are equally important to the success of this experiment. So try not to concentrate exclusively on any one particular task to the neglect of the others. You will receive a few second's spoken warning from the experimenters over the communication system before each task is presented.

It is essential to the success of this experiment that you complete all conditions and that you do as well as you can in performing your assigned tasks at all times, whether or not the particular conditions present at the time seem stressful to you. Never abandon a task, even if you do not think you are doing very well at it.

Please make sure that you have read these general instructions and the instructions for the individual tasks thoroughly and that you understand all aspects before beginning the experiment. During your training runs, do not hesitate to ask the experimenters at any time if an instruction is not clear: there won't be time for a chat during the experimental runs.

During experiments, try to avoid making comments of a non-essential nature while you are actually engaged in any task, but feel free to comment on any aspect of the tasks or the experimental conditions between times. We are interested in your subjective reactions, symptoms and impressions, as well as in your efficiency in performing the tasks, which we shall be monitoring continuously.

It is important that you complete all tasks in each run as scheduled without a break, but if you feel at any time that you seriously need to stop a run, call out and it can be terminated immediately.

EXHIBIT A

EXPERIMENTAL CONDITIONS

(Instructions to Subjects)

Frequency (Hz)	Exposure Time (Min)	Acceleration Level (g)
0*	16	(0)
0*	25	(0)
2	16	.137
2	16	.433
2	25	..113
2	25	.361
4	16	.096
4	16	.305
4	25	.082
4	25	.260
8	16	.096
8	16	..305
8	25	.082
8	25	.260

* Control run with no vibration.

EXHIBIT B

PRE- AND POST-VIBRATION PERIODS

(Instructions to Subjects)

Pre-Vibration

<u>Time</u>	<u>Activity</u>
-30	Subject reception and briefing
-26	Urine sample (Exhibit D)
-24	Don headgear, electrodes (Exhibit E)
-18	Sway/tremor Test (Exhibit F and G)
-15	Kinesthetic Test (Exhibit H)
-12	Manual Dexterity Test (Exhibit I)
-10	Board Vibration Machine and make connections
-06	Critical Flicker Fusion Test (Exhibit J)
-04	Vasomotor Test (Exhibit K)
-02	Dynamometer Test (Exhibit L)
-01	Prepare to run

Post-Vibration

00	Critical Flicker Fusion
02	Vasomotor Test
04	Dynamometer Test
05	Disconnect, Dismount
06	Sway/tremor Test
09	Kinesthetic Test
12	Manual Dexterity
15	Remove headgear, electrodes
21	Urine sample
23	Critical Flicker Fusion Test
25	Vasomotor Test
27	Dynamometer Test
29	Sway/tremor Test
31	Kinesthetic Test
34	Manual Dexterity Test
37	Debriefing

EXHIBIT C

VIBRATION PERIOD*
(Instructions to Subject)

16-Minute Runs

Activity	Time 0	_____	16 minutes.
Vibration (Exhibit A)		_____	
Tracking (Exhibit M)		_____	
Secondary Task (Exhibit N or O)		_____	
Visual Acuity (Exhibit Q, R, or S)		_____	
TDR (Exhibit P)**			↑
MSR (Exhibit T)***			↑

25-Minute Runs

Activity	Time 0	_____	25 minutes.
Vibration (Exhibit A)		_____	
Tracking (Exhibit M)		_____	
Secondary Task (Exhibit N or O)		_____	
Visual Acuity (Exhibit Q, R, or S)		_____	
TDR (Exhibit P)**			↑
MSR (Exhibit T)***			↑

*Or control run without vibration.
**Task Difficulty Rating.
***Motion Severity Rating.

URINE SPECIMENS (MEN)

(Instructions to Subjects)

On each occasion when a urine sample is called for (normally a few minutes before and after each vibration or control run), you will be provided with a clean, individually labelled container for the specimen. (The containers will be identified by subject number only, not by name.)

Take the container to the men's room. Urinate first into the toilet bowl (not the container) for approximately two seconds, then pause, and transfer the stream of urine to the container. Try to fill the container approximately to the half-way level: do not over-fill it. Then pause again and discard any further urine you have to pass into the bowl.

If, when you begin, you find that you have only a small amount of urine to pass (less than half a container), then pass all of it into the container, without discarding any.

As soon as you have finished in the men's room, please take the container back to the experiment room and return it to the experimenters without delay. The container will be provided by a male member of the UDRI staff and should be returned to the same person.

Important: Please inform either the person providing the container or the Principal Investigator (Dr. J. C. Guignard, UDRI, telephone 229-3216) if you have noticed any discharge or bleeding from your urinary opening (at the end of the penis) or sustained any injury to your groin or pelvic area within the seven days preceding your first specimen of the day. Any such information which you provide will be treated as strictly confidential, in the same manner as the medical history which you have already provided.

EXHIBIT E

HEADGEAR AND CHEST ELECTRODES

(Instructions to Subjects)

In all vibration and control runs you will be asked to wear some head-mounted equipment; and in most runs (except some very short runs) you will also be asked to wear some stick-on chest electrodes which we use to record your heartbeat. Here are some details of the equipment.

Headgear

(1) Mouthpiece

This is the light plastic device which clips onto your upper teeth, for which you will have been fitted individually by the dentist. It is your own personal, named mouthpiece, which we keep in the laboratory for your own exclusive use. Nobody else will (or can) ever wear it. It should be cleaned with fresh water and put away dry after every use: a small box will be provided to keep it in.

During each run, the mouthpiece will be used to carry a miniature vibration-measuring device (a strain-gage transducer), just in front of your lower lip, so that the instrument follows the motion of your head. The insulated wire carrying signals from the instrument (transducer) are lightly taped to one side of your face and led off over your shoulder, in a convenient and comfortable manner. You will be asked to clip the mouthpiece onto your own teeth before each run; and to remove it carefully after the run. You will be told when to do this. With a little practice, you can speak quite easily with the mouthpiece in place. Removal of the device is best done by hooking a fingernail above the margin of the mouthpiece where it runs back over your upper teeth on each side. Do not use the part that sticks out of your mouth as a lever, or you may damage the device. Handle it gently at all times: this is especially important when the transducer is fixed to the mouthpiece, for the instrument is very fragile.

(2) Headpiece

A light metal headpiece is to be fitted to the back of your head before each run. It carries another transducer (similar to the one on the mouthpiece) to measure the vibration at the back of your head. The headpiece is attached by means of individually adjustable self-sticking straps passing around your forehead (like a headband) and under your chin. One of the experimenters will help you to put it on and adjust it. It should be as tight as possible without being uncomfortable for you. The insulated wire from the transducer will be led off to your rear.

(3) Headset

In all runs, you will also be asked to wear a set of earphones, similar to the ones you used for your audiogram. These will be put on over the headpiece (2) shortly before the run. They should be adjusted as snugly as possible to cover your ears without discomfort. You should tell us whether the fit is satisfactory or not before the run begins. The wire from the headset will be led off to your rear and lightly clipped to your clothing.

The earphones will produce a constant hissing noise at a steady level throughout all runs. This is to mask outside noises which might otherwise distract you from your tasks during the run. We shall also use the earphones as an intercom to give you spoken messages. The same earphones are also used to present the "beeps" in those runs in which you do the Auditory Vigilance Task (Exhibit O).

Chest Electrodes ("EKG leads")

An individual set of 3, medical-type, heartbeat monitoring electrodes will be stuck to the skin of your chest (front and to the side) to wear throughout all runs exceeding 1 minute's duration. They are of an easy-to-use, disposable type widely used to monitor the condition of patients in hospitals (and astronauts in space)

EXHIBIT E (Continued)

One of the experimenters will attach the electrodes and take them off for you (women subjects will be fitted in privacy by a female member of the research team). To put the electrodes on correctly, small areas of your skin must first be prepared with a rubbing alcohol swab. Then the electrode is attached to the skin with firm pressure. It contains a small quantity of a special jelly which carries the small electrical signals generated by your heartbeat to the recording electrocardiograph (EKG) machine. The electrodes adhere to the skin by means of a sticky material resembling Scotch tape. Nothing will penetrate the skin. This type of electrode can be worn for over 24 hours and easily removed without discomfort. The fine insulated wires from the electrodes will be led out through a convenient opening in your clothing.

General Instructions

Please be sure that all the head and chest attachments described above are snug and comfortable before the run begins.

If any part of the equipment should begin to feel too loose, too tight, or in any way uncomfortable during the run, please inform the experimenters in a clear voice. Do not try to readjust any of the equipment yourself. Someone will come to your side to inspect it; and, if necessary, we will interrupt the run to make adjustments.

EXHIBIT H

KINESTHETIC TEST: 2-POINT DISCRIMINATION

(Instructions to Subjects)

This quick and simple test will measure the sensitivity of touch in your hands. It will be performed with you seated at a table upon which is a thick metal bar, (one of two), with slots cut in it. The slots vary from one inch to a few thousands of an inch in width.

The experimenter will ask you to close your eyes and keep them closed. Your hand will then be guided to a slot in one of the bars and placed so that the inner palm (little finger) side of your hand rests on a slot. Allow your hand to be placed passively: Do not slide it up or down the bar. If you feel the slot (that is, if you definitely detect its two distinct edges), you should say "Yes". If you cannot feel it, you should say "No". (You may feel a single edge, or nothing but smooth metal.) The experimenter will continue to move your hand up and down the bar, with you answering either "Yes" or "No", for several positions.

This procedure will next be repeated using the tip of your index finger on the same hand. The whole sequence (palm and finger) will then be repeated using your other hand.

Remember to keep your eyes closed; and always be sure that you can definitely feel two separate edges to the slot before saying "Yes". If you seem to be feeling plain metal (which sometimes will be the case), or if you are not certain whether a slot is there or not, say "No".

EXHIBIT I

MANUAL DEXTERITY: ONE HOLE TEST

(Instructions to Subjects)

You will be seated at a table when performing this task. A wedge shaped box with a dished tray at the bottom front and a small hole in the top will be in front of you. The tray will either be positioned to the right or left of center, depending on your dominant hand. Your free hand must rest on the rectangular chrome plate in front of the tray during testing.

After being told to start, your task will be to grasp the small metal pin which appears in the tray and place it in the hole on the top of the apparatus as promptly as possible. Another pin will immediately appear in the dished tray at the bottom of the box. You will continue to move pins from the tray to the hole until told to stop. The test will last for approximately one minute. We shall be scoring how many pins you can move in that time, so keep at it, working as swiftly as you can.

The time you take to grasp a pin and the time you take to insert the pin in the hole is also being recorded. The greater the number of pins you place and the shorter your grasping and placing times, the better your score.

Remember to move only one pin at a time; and keep your free hand on the chrome rectangle. If you drop a pin, keep right on working, the experimenter will retrieve it while the next pin appears.

EXHIBIT J

FLICKER FUSION TASK

(Instructions to Subjects)

This test is performed before and after each vibration or control run but not during the run. The apparatus will be located within reach to the left of your vibration chair. It has a peepshow-type double eyepiece in which you can see flickering light patches. You should adjust the double eyepiece to a convenient angle by hand and look into the shielded eyepiece so that you can attend closely to the two patches of light inside, which will be flashing on and off. We shall vary the speed with which the lights flash. Your first task during this test will be to examine the lights until they are no longer flashing and appear as two steady, continuous lights. The speed of flashing will be increased until this happens. Inform the Experimenter by saying "Now" as soon as both lights appear to be shining steadily and continuously (no longer flickering).

Your second task is to continue observing the patches of light which you have now determined to be steady light. The speed of flashing will change anew. You should say "Now" again as soon as the lights appear once more to flash on and off (ie, to flicker again).

NOTE: This two-part procedure will be repeated several times in succession, so that we can make several measures of your responses.

EXHIBIT K

VASOMOTOR REACTION TIME TEST

(Instructions to Subjects)

This is a very brief and simple test to see whether gripping the handles of the vibrating seat has any temporary effect upon the speed with which blood flows in the skin of your hand and forearm. We test this before and after every run.

The experimenter will ask you to hold out one of your hands with the palm down. The experimenter will then gently but firmly grasp your hand, exerting firm pressure with his thumb on the back of your hand for a few seconds. This leaves a relatively pale patch (the size of the experimenter's thumbprint) on your hand which lasts a few more seconds before fading away. (It is quite easy to demonstrate this effect on yourself, using one hand to grasp the other.) The fading-time will be measured using a stopwatch. This procedure is repeated several times.

It is not always possible to get the pale skin reaction using the method described above, in which case we may sometimes need to use a different technique. That makes use of a blunt instrument (a rubber pencil eraser) to firmly stroke your forearm from a little below the elbow to a little above the wrist. Such action normally leaves a pale streak on the forearm. The streak takes a few seconds to disappear; and the fading-time is again measured using a stopwatch.

EXHIBIT L

DYNAMOMETER (Instructions to Subjects)

This quick and simple test will measure your grip strength. It is measured using a metal hand grip comprised of two concentric rings (dynamometer). A dial in kilograms is attached to the two rings.

After positioning your fingers in the inner ring, your task is to squeeze the two rings together as hard as you can. You are to use only one hand when gripping the rings and hold the apparatus at your side while applying pressure so you can not read the dial. After squeezing, show the instrument to the experimenter, who will read the dial before resetting it to zero. You repeat this task three times on each hand. (We will start with your dominant hand.)

EXHIBIT M

TRACKING TASK

(Instructions to Subjects)

On the display in front of you is a needle on a dial. You will be told when to begin tracking. The needle will be in the center when the test begins, but will immediately start to wander. You can correct the wandering by means of the foot pedal on your right side.

The object is to keep the needle as close to the central "50" marking on the dial as possible. Pressing the pedal down moves the needle to the right. Releasing the pedal moves the needle to the left. The task is similar to holding a constant speed in an automobile while traveling up and down a rolling roadway.

Your error score will be monitored continuously during each of the experimental periods in which you are asked to track. Your error score will be based not only on the length of time the needle is off the "50" mark, but also on how far the needle is from that mark. Keep the needle as close to the "50" mark as possible all the time. You will be told when the task has been completed.

NOTE: While tracking, you will also be performing a Secondary Task, namely, either the Attentional Selectivity Task (Exhibit N) or the Auditory Vigilance Task (Exhibit O). Your primary task is tracking, but please do not neglect or abandon performance of the other task.

EXHIBIT N

ATTENTIONAL SELECTIVITY TASK

(Instructions to Subjects)

This task is performed at the same time as the Tracking Task. A horizontal array of lights is set up in an arc on each side of the tracking task dial in front of you. Any one of these lights (but never more than one at a time) may light up during the experimental test period. Your task is to cancel the appearance of a light as quickly as possible, using the thumb-button on top of your right hand-grip.

The time you take to cancel each light, and also the number (hopefully none) to which you fail to respond, will be used in scoring your performance. The shorter the time and the fewer lights missed, the better your score. If you fail to respond to any light within a predetermined time it will eventually go out again automatically, but the total burn time will be added to your score.

NOTE: While performing this light-cancelling task, you must also continue to perform the Tracking Task (Exhibit M). Your primary task is tracking, but please do your best to respond to the lights throughout the run. The lights will only come on while you are performing the Tracking Task.

EXHIBIT P

TASK DIFFICULTY ("TD") RATING

(Instructions to Subjects)

You are asked to use a 9-point scale to give your personal rating of the Task Difficulty you experience in performing the main tasks (Tracking and Secondary Tasks) during each run. This rating deals only with how easy or difficult you found the tasks. It should not include judgement of the environmental conditions. You use the same scale whether vibration is present or not. We need one rating at the end of your performance of the Tracking and Secondary Tasks in each experimental condition. As soon as those tasks are completed, you will be asked to announce your "TD Rating". It is important that you make each rating independently. In other words, do your best to treat each rating occasion as a fresh situation without letting your judgement be influenced by any ratings which you may have made earlier, or in other experiments.

Before the experiment begins, please familiarize yourself with the phrases on the 9-point Task Difficulty Rating Scale provided and memorize the corresponding numbers.

TASK DIFFICULTY ("TD") SCALE

1. Extremely Easy
2. Very Easy
3. Easy
4. Not Very Easy
5. Middling
6. Not Very Difficult
7. Difficult
8. Very Difficult
9. Extremely Difficult

EXHIBIT P (Continued)

NOTE: The numbers on this scale do not necessarily correspond with similar numbers on other scales you may use during this experiment.

When you are asked to make "TD" ratings during the experiment, please rate the ease or difficulty with which you performed the tasks in that particular run. We want your immediate impressions. Do not worry about what ratings you may have given before. Using the guidance provided by the nine phrases on the "TD" scale, select the one which best describes your judgement of the ease or difficulty which you were experiencing in that run. The number of the phrase is your "TD Rating". For instance, if you were to decide that the phrase "Easy" best describes your tasks during that run, you would say "TD Number Three"; or if you thought the phrase "Difficult" most appropriate, you would say "TD Number Seven". Please make a firm decision as soon as possible when asked and announce it clearly: only one number can be recorded for any rating (we cannot score afterthoughts). The experimenter will record that number alone as your "TD Rating".

EXHIBIT Q

VISUAL ACUITY (BROKEN RING) TEST

(Instructions to Subjects)

This test is to measure your sharpness of vision (distance eyesight). It is presented during your training runs and during vibration and control runs. It takes about one minute to perform.

You will be told when the "Broken Rings" are about to appear. They are covered by the movable panel labelled "Visual Tests". The cover will be removed, revealing a view (seen through a mirror beyond the enclosure in front of you) of 36 small broken rings. They are printed in black on a white card and look like this: C This one is shown with the "break" to the right ("three o'clock" position).

The rings are arranged in 6 rows of 6 but each ring has the break pointing in a different direction. The directions are identified by the hours of the clock. Here are some examples:

- C "Three o'clock"
- o "Eight o'clock"
- o "Twelve o'clock"

Your task is to read each row as quickly but as accurately as possible, from left to right. Call out the positions in a firm, clear voice. You should identify each row, "Row One", "Row Two" and so on, before calling out the successive clock positions. For example, if the top row looked like this:

o o o C o o

your response should be "Row One: six o'clock, one o'clock, nine o'clock, three o'clock, ten o'clock, one o'clock". (It is possible for the same position to occur more than once in the same row; or twice in succession, although this is not common). As soon as you have read Row One, announce "Row Two" and go right on in the same way until you have read all six rows. The test is then ended.

EXHIBIT Q (Continued)

If you cannot be sure of the position of a particular ring, do your best to guess. DO NOT REMAIN SILENT. We score all of your replies, so we must have six answers (even though some may be wrong) for every row of rings presented to you.

It is important that you read out the positions as quickly as you comfortably can, but it is even more important that you do your best to get them right. Remember, if you really cannot be sure of a position, make a guess. Try not to worry overly long about any particular ring. (If your progress is unusually slow, we may have to cut off the display before you have finished all six rows, and only the rings you have managed to complete will be scored.)

EXHIBIT T

MOTION SEVERITY "MS" RATING

(Instructions to Subjects)

You are asked to use a 9-point scale to give your rating of the Motion Severity (degree of gentleness or roughness) of the up-and-down motion (vibration) which you are experiencing at the moment. You will be asked to announce your "MS Rating" near the end of each run. It is important that you make each rating independently. In other words, do your best to treat each occasion on which you are asked to make an "MS" rating as a fresh situation, without letting your judgement be influenced by any ratings which you may have made earlier, or in other experiments.

Before the experiment begins, please familiarize yourself with the phrases on the 9-point Motion Severity Rating Scale provided and memorize the corresponding numbers.

MOTION SEVERITY ("MS") SCALE

1. Extremely Gentle
2. Very Gentle
3. Gentle
4. Not Very Gentle
5. Middling
6. Not Very Rough
7. Rough
8. Very Rough
9. Extremely Rough

NOTE: The numbers on this scale do not necessarily correspond with similar numbers on other scales you may use during this experiment.

EXHIBIT T (Continued)

When you are asked to make a "MS" rating during the experiment, please rate the VIBRATION (up-and-down motion) as it affects you at the moment. We want your immediate impressions. Do not worry about what ratings you may have given before. Using the guidance provided by the nine phrases on the "MS" scale, select the one which best describes your judgement of the vibration which you are experiencing. The number of that phrase is your rating. Please make a firm decision as soon as possible when asked: only one number can be recorded for any rating (we cannot score afterthoughts). When you have made up your mind, call out clearly "MS Number" giving the appropriate number. The experimenter will then record that number as your "MS Rating". For example, if you think that the vibration you are experiencing is "Gentle" during a particular run, you should call out "MS Number Three"; or, if you think the phrase "Very Rough" best describes the vibration, you should say "MS Number Eight".

INCENTIVE PROGRAM
(Instructions to Subjects)

In addition to the regular hourly wage, every Subject will be awarded additional pay in the form of a performance bonus. The purpose of this bonus is to reward Subjects who maintain reasonable alertness and effort on the tracking task and discourage inattentive performance. The size of your bonus will be determined by your tracking error score following each tracking session (15 or 24 minutes). As your tracking accuracy increases the size of your bonus will increase and vice versa. There is no "cut off" tracking score above which you will receive a large bonus or below which you will receive no bonus. Rather, each Subject's tracking score will be compared with a standardized scale to determine bonus size. Bonuses will be awarded following completion of each time series (16 minute, 25 minute, 2-1/2 hour, 4 hour, and 8 hour) of vibration runs.

UNIVERSITY OF DAYTON RESEARCH INSTITUTE

VIBRATION SUBJECT'S INSTRUCTIONS

Human Vibration Experiment UDRI(NIOSH) - 5-RO1-OH-00479-02

"Effects of Vibration on Human Comfort and Performance"

Series 2 Long Duration Experiments

Run durations 2-1/2, 4, 8 hour(s)

Location: Building _____, Area B, WPAFB - Telephone - _____

Scheduling Inquiries: WPAFB - Telephone 255- _____

General Inquiries: Research Institute - Telephone 229-3216

GENERAL INSTRUCTIONS*

(2-1/2, 4, and 8 Hour Runs)

Purpose

This experiment is one in a series designed to evaluate systematically the current human vibration exposure limits established by the International Organization for Standardization for whole-body vibration affecting man (ISO 2631-1974). The vibration exposures are determined according to the "Fatigue-Decreased Proficiency (FDP) Boundary defined in that International Standard.

Nature of Experiment

The experiment will involve a measurement of your performance on a group of psychological and physiological tasks. While performing the tasks, you will be seated on a tractor type seat, firmly mounted on a vibration machine which we use to apply vibration to your seat and footrests in the vertical direction (up and down). You will wear a lapbelt, a headset (used to provide noise and signals used in one of the tasks), and some external instrumentation, used to record your heart beat (stick-on electrodes) and the amount of vibration transmitted to your head from the seat (miniature lightweight accelerometers mounted on an individually molded mouthpiece).

You are required to attend a minimum of 11 experimental sessions. The first two attendances will be used solely for familiarization with the experimental procedure and training on the performance tests. Each training session will last 3 hours. The remaining 9 attendances are experimental sessions in which the vibration conditions will be presented in a random order. Three of the nine sessions will last 4 hours, three 5 hours and the remaining 3 - 10 hours each including lunch.

Vibration Conditions

On each of the 9 experimental sessions, you will carry out the same test procedure but will undergo a different condition of vibration. The frequency of vibration (number of cycles per second) will vary, from 2 cps (resembling a trotting horse) to 4 cps (resembling the vibration of an idling diesel engine). The length of time over which you will experience vibration will be either 2-1/2, 4 or 8 hours. The acceleration (intensity) of the vibration is determined by exposure time (2-1/2, 4, 8 hours) and frequency (2, or 4 cps), but on no occasion will it exceed one half the value permitted by the Exposure Limit set by ISO for human daily vibration exposure. The intensity will be comparable with motion experienced while driving a working vehicle (eg, tractor, truck). One of the 2-1/2, 4, or 8 hour sessions will be a control condition during which you will perform the tasks in the same manner but the seat will not be vibrated.

*It is essential that you study these instructions carefully. Do not hesitate to ask for a fuller explanation if any point is not entirely clear to you.

You will be scheduled so that you do not undergo vibration testing any more than once in every 24 hours. Also, you are requested NOT to take part in activities such as violent recreation, wild parties or drinking less than 24 hours before training or experimental periods.

Tests

Before and after each vibration session, you will perform a series of quick and simple tests. All tests will always be presented in the same order regardless of the vibration exposure level or duration. The testing schedule for Pre-Vibration and Post-Vibration sessions is given in Exhibit B. Particular tests are explained further in their respective Exhibits.

During the vibration and 3 control experimental sessions, your performance of additional tasks will be measured. The major part of your time will be spent working on a combination of two tasks, namely "Tracking" (primary task, Exhibit M) and a secondary task. Your sharpness of vision will also be tested at regular intervals during vibration. You will also subjectively rate your personal impressions of the vibration conditions in which you are working, and the task difficulty. The testing schedule is given in Exhibit C. Each performance task is explained in detail in following Exhibits.

Optional Personality Test

You may also be asked to carry out a simple, standard personality test, which we sometimes use to interpret the results of the subjective ratings of vibration exposure. However, the personality test will be conducted on an entirely voluntary basis: you may refuse to take it without prejudice to your application for membership on the Vibration Subject Panel. If you do take the personality test (as we hope you will), the results will again be treated as entirely confidential between yourself and the Experimenters. Individual subjects will not be identifiable from published results of the experiments.

The Experimenters and Location

This project is funded by a grant (#1.R01 OH-00479-01) from the National Institute of Occupational Safety and Health (NIOSH), US Department of Health, Education and Welfare to the Co-Principal Investigators at UDRI; Dr. J. C. Guignard, Adjunct Research Physiologist and Mr. G. J. Landrum, Research Psychologist. The experimentation will be conducted by Mr. G. J. Landrum and Mr. R. E. Reardon, Research Psychologist (UDRI 229-3216). The vibration experiments will be carried out at Wright-Patterson Air Force Base, Area B, where the USAF Aerospace Medical Research Laboratory is making man-rated vibration machines available for our use. Apart from providing these machines for use by UDRI under an inter-agency agreement with NIOSH, the Air Force will play no part in the direction or conduct of the experiments.

Scheduling of your attendances, and credentials to enter the Base, as well as reimbursement for all time given by you to this project (on an hourly basis) will be organized by Mr. Landrum and Mr. Reardon. The qualifying

physical examination will be conducted at Wright State University by a physician. Chandler A. Phillips, M.D. Appointments will be arranged by Mr. Landrum.

Do's and Don'ts (All Runs)

(a) On the day (ie, at least 24 hours)/before any scheduled run:

PLEASE DO NOT

- (1) Engage in violent, noisy, or excessively active pursuits or recreations (eg, motorcycling, powerboating, snowmobiling, horseback riding, skiing, karate, Note: if you are a footballer or other UD team game player who must practice regularly please advise us regarding your schedule or have your Coach discuss it with us.)
- (2) Indulge in alcohol, pot, or other drugs.
- (3) Attend concerts, parties, discos (or listen to home stereo) where the sound level is likely to be excessive (ie, loud enough to affect your hearing or make your ears ring afterwards or to make it necessary to shout to converse face-to-face during the musci).

PLEASE DO

- (1) Inform the Experimenters (Bldg. 93/Phone: 255-2631 or the Research Secretary/Phone: 229-3216) if you have a cold or any other illness (including toothache) or if for any other reason it is necessary for you to reschedule your run.
- (2) Remember to tell the Experimenters prior to each run if you have undergone any changes in your medical status or are taking any medication.

(b) On the day of any scheduled run:

PLEASE DO NOT

- (1) Be late.
- (2) Smoke in the experiment room.
- (3) Attend if you are unwell (you can always reschedule your run if you do not feel well).

PLEASE DO

- (1) Wear reasonably "sensible" everyday clothing and footwear. Avoid heavy boots and shoes with high heels or high platform soles. Avoid trailing garments. Avoid stiff and heavy garments (eg, combat jackets with bulging pockets). Women subjects should wear jeans or slacks and whatever breast support they normally feel most comfortable with when riding in vehicles. Men and women subjects with long hair should bring a lightweight clasp or tie to hold the hair behind the neck.
- (2) Try to wear the same (or similar) footwear and clothing on each attendance. This is important because these items can influence your response to vibration.

- (3) Let us know as early in the day as possible (255-2634 or if no answer 229-3216) if for any reason you have to cancel your scheduled attendance.

(c) At any time:

PLEASE DO NOT

Discuss with other subjects (or potential subjects) your performance of any of the tasks, the numbers which you or they have given in the subjective rating tests, or the answers you may have given in the personality test. We make this request especially to avoid the possibility of one subject accidentally influencing the results of another.

IMPORTANT

Your scores in all tasks are equally important to the success of this experiment. So try not to concentrate exclusively on any one particular task to the neglect of the others. You will receive a few second's spoken warning from the experimenters over the communication system before each task is presented.

It is essential to the success of this experiment that you complete all conditions and that you do as well as you can in performing your assigned tasks at all times, whether or not the particular conditions present at the time seem stressful to you. Never abandon a task, even if you do not think you are doing very well at it.

Please make sure that you have read these general instructions and the instructions for the individual tasks thoroughly and that you understand all aspects before beginning the experiment. During your training runs, do not hesitate to ask the experimenters at any time if an instruction is not clear: there won't be time for a chat during the experimental runs.

During experiments, try to avoid making comments of a non-essential nature while you are actually engaged in any task, but feel free to comment on any aspect of the tasks or the experimental conditions between times. We are interested in your subjective reactions, symptoms and impressions, as well as in your efficiency in performing the tasks, which we shall be monitoring continuously.

It is important that you complete all tasks in each run as scheduled without a break, but if you feel at any time that you seriously need to stop a run, call out and it can be terminated immediately.

EXHIBIT A

EXPERIMENTAL CONDITIONS

(Instructions to Subjects)

Frequency (Hz)	Exposure Time (Hours)	Acceleration Level (g)
0*	2.5	.000
2	2.5	.144
4	2.5	.102
8	2.5	.102
16	2.5	.203
32	2.5	.404
0*	4.0	.000
2	4.0	.108
4	4.0	.076
8	4.0	.076
16	4.0	.153
32	4.0	.306
0*	8.0	.000
2	8.0	.065
4	8.0	.045
8	8.0	.045
16	8.0	.091
32	8.0	.180

*Control run with no vibration.

EXHIBIT B

PRE- AND POST-VIBRATION PERIODS

(Instructions to Subjects)

Pre-Vibration

<u>Time</u>	<u>Activity</u>
-30	Subject reception and briefing
-26	Electrode placement (Exhibit E)
-24	Urine sample (Exhibit D)
-18	Sway platform (Exhibit F)
-15	Kinesthetic Test (Exhibit H)
-12	Manual Dexterity Test (Exhibit I)
-10	Board Vibration Machine and make connections
-06	Critical Flicker Fusion Test (Exhibit J)
-04	Vasomotor Test (Exhibit K)
-02	Dynamometer Test (Exhibit L)
-01	Don headset and mouthpiece

Post-Vibration

<u>Time</u>	<u>Activity</u>
00	Critical Flicker Fusion Test
02	Vasomotor Test
04	Dynamometer Test
05	Disconnect and Dismount Vibration Machine
06	Sway platform
09	Kinesthetic Test
12	Manual Dexterity Test
15	Urine sample and Remove Electrodes
18	Debriefing

EXHIBIT C

VIBRATION PERIOD*

(Instructions to Subject)

30-Minute Blocks

<u>Activity</u>	Time 0	30 minutes
Vibration (Exhibit A)	_____	_____
Tracking (Exhibit M)	_____	_____
Secondary Task (Exhibit N or O)	_____	_____
Visual Acuity (Exhibit Q, R, or S)	_____	_____
Task Difficulty Rating (Exhibit P)		↑
Motion Severity Rating (Exhibit T)		↑

*Or control run without vibration.

EXHIBIT D (M)

URINE SPECIMENS (MEN)

(Instructions to Subjects)

On each occasion when a urine sample is called for (normally a few minutes before and after each vibration or control run), you will be provided with a clean, individually labelled container for the specimen. (The containers will be identified by subject number only, not by name.)

Take the container to the men's room. Urinate first into the toilet bowl (not the container) for approximately two seconds, then pause, and transfer the stream of urine to the container. Try to fill the container approximately to the half-way level: do not over-fill it. Then pause again and discard any further urine you have to pass into the bowl.

If, when you begin, you find that you have only a small amount of urine to pass (less than half a container), then pass all of it into the container, without discarding any.

As soon as you have finished in the men's room, please take the container back to the experiment room and return it to the experimenters without delay. The container will be provided by a male member of the UDRI staff and should be returned to the same person.

Important: Please inform either the person providing the container or Co-Principal Investigator (Mr. G. J. Landrum, UDRI, telephone 229-3216) if you have noticed any discharge or bleeding from your urinary opening (at the end of the penis) or sustained any injury to your groin or pelvic area within the seven days preceding your first specimen of the day. Any such information which you provide will be treated as strictly confidential, in the same manner as the medical history which you have already provided.

HEADGEAR AND CHEST ELECTRODES

(Instructions to Subjects)

In all vibration and control runs you will be asked to wear some head-mounted equipment; and in most runs (except some very short runs) you will also be asked to wear some stick-on chest electrodes which we use to record your heartbeat. Here are some details of the equipment.

Headgear

(1) Mouthpiece

This is the light plastic device which clips onto your upper teeth, for which you will have been fitted individually by the dentist. It is your own personal, named mouthpiece, which we keep in the laboratory for your own exclusive use. Nobody else will (or can) ever wear it. It should be cleaned with fresh water and put away dry after every use: a small box will be provided to keep it in.

During each run, the mouthpiece will be used to carry a miniature vibration-measuring device (a strain-gage transducer), just in front of your lower lip, so that the instrument follows the motion of your head. The insulated wire carrying signals from the instrument (transducer) are lightly taped to one side of your face and led off over your shoulder, in a convenient and comfortable manner. You will be asked to clip the mouthpiece onto your own teeth before each run; and to remove it carefully after the run. You will be told when to do this. With a little practice, you can speak quite easily with the mouthpiece in place. Removal of the device is best done by hooking a fingernail above the margin of the mouthpiece where it runs back over your upper teeth on each side. Do not use the part that sticks out of your mouth as a lever, or you may damage the device. Handle it gently at all times: this is especially important when the transducer is fixed to the mouthpiece, for the instrument is very fragile.

EXHIBIT E (Continued)

(2) Headset

In all runs, you will also be asked to wear a set of earphones, similar to the ones you used for your audiogram. These will be put on over the headpiece (2) shortly before the run. They should be adjusted as snugly as possible to cover your ears without discomfort. You should tell us whether the fit is satisfactory or not before the run begins. The wire from the headset will be led off to your rear and lightly clipped to your clothing.

The earphones will produce a constant hissing noise at a steady level throughout all runs. This is to mask outside noises which might otherwise distract you from your tasks during the run. We shall also use the earphones as an intercom to give you spoken messages. The same earphones are also used to present the "beeps" in those runs in which you do the Auditory Vigilance Task (Exhibit O).

Chest Electrodes ("EKG leads")

An individual set of 3, medical-type, heartbeat monitoring electrodes will be stuck to the skin of your chest (front and to the side) to wear throughout all runs exceeding 1 minute's duration. They are of an easy-to-use, disposable type widely used to monitor the condition of patients in hospitals (and astronauts in space).

One of the experimenters will attach the electrodes and take them off for you (women subjects will be fitted in privacy by a female member of the research team). To put the electrodes on correctly, small areas of your skin must first be prepared with a rubbing alcohol swab. Then the electrode is attached to the skin with firm pressure. It contains a small quantity of a special jelly which carries the small electrical signals generated by your heartbeat to the recording electrocardiograph (EKG) machine. The electrodes adhere to the skin by means of a sticky material resembling Scotch tape. Nothing will penetrate the skin. This

EXHIBIT E (Continued)

type of electrode can be worn for over 24 hours and easily removed without discomfort. The fine insulated wires from the electrodes will be led out through a convenient opening in your clothing.

General Instructions

Please be sure that all the head and chest attachments described above are snug and comfortable before the run begins.

If any part of the equipment should begin to feel too loose, too tight, or in any way uncomfortable during the run, please inform the experimenters in a clear voice. Do not try to readjust any of the equipment yourself. Someone will come to your side to inspect it; and, if necessary, we will interrupt the run to make adjustments.

EXHIBIT H

KINESTHETIC TEST: 2-POINT DISCRIMINATION

(Instructions to Subjects)

This quick and simple test will measure the sensitivity of touch in your hands. It will be performed with you seated at a table upon which is a thick metal bar, (one of two), with slots cut in it. The slots vary from one inch to a few thousands of an inch in width.

The experimenter will ask you to close your eyes and keep them closed. Your hand will then be guided to a slot in one of the bars and placed so that the inner palm (little finger) side of your hand rests on a slot. Allow your hand to be placed passively: Do not slide it up or down the bar. If you feel the slot (that is, if you definitely detect its two distinct edges), you should say "Yes". If you cannot feel it, you should say "No". (You may feel a single edge, or nothing but smooth metal.) The experimenter will continue to move your hand up and down the bar, with you answering either "Yes" or "No", for several positions.

This procedure will next be repeated using the tip of your index finger on the same hand. The whole sequence (palm and finger) will then be repeated using your other hand.

Remember to keep your eyes closed; and always be sure that you can definitely feel two separate edges to the slot before saying "Yes". If you seem to be feeling plain metal (which sometimes will be the case), or if you are not certain whether a slot is there or not, say "No".

EXHIBIT I

MANUAL DEXTERITY: ONE HOLE TEST

(Instructions to Subjects)

You will be seated at a table when performing this task. A wedge shaped box with a dished tray at the bottom front and a small hole in the top will be in front of you. The tray will either be positioned to the right or left of center, depending on your dominant hand. Your free hand must rest on the rectangular chrome plate in front of the tray during testing.

After being told to start, your task will be to grasp the small metal pin which appears in the tray and place it in the hole on the top of the apparatus as promptly as possible. Another pin will immediately appear in the dished tray at the bottom of the box. You will continue to move pins from the tray to the hole until told to stop. The test will last for approximately one minute. We shall be scoring how many pins you can move in that time, so keep at it, working as swiftly as you can.

The time you take to grasp a pin and the time you take to insert the pin in the hole is also being recorded. The greater the number of pins you place and the shorter your grasping and placing times, the better your score.

Remember to move only one pin at a time; and keep your free hand on the chrome rectangle. If you drop a pin, keep right on working, the experimenter will retrieve it while the next pin appears.

EXHIBIT J

FLICKER FUSION TASK

(Instructions to Subjects)

This test is performed before and after each vibration or control run but not during the run. The apparatus will be located within reach to the left of your vibration chair. It has a peepshow-type double eyepiece in which you can see flickering light patches. You should adjust the double eyepiece to a convenient angle by hand and look into the shielded eyepiece so that you can attend closely to the two patches of light inside, which will be flashing on and off. We shall vary the speed with which the lights flash. Your first task during this test will be to examine the lights until they are no longer flashing and appear as two steady, continuous lights. The speed of flashing will be increased until this happens. Inform the Experimenter by saying "Now" as soon as both lights appear to be shining steadily and continuously (no longer flickering).

Your second task is to continue observing the patches of light which you have now determined to be steady light. The speed of flashing will change anew. You should say "Now" again as soon as the lights appear once more to flash on and off (ie, to flicker again).

NOTE: This two-part procedure will be repeated several times in succession, so that we can make several measures of your responses.

EXHIBIT K

VASOMOTOR REACTION TIME TEST

(Instructions to Subjects)

This is a very brief and simple test to see whether gripping the handles of the vibrating seat has any temporary effect upon the speed with which blood flows in the skin of your hand and forearm. We test this before and after every run.

The experimenter will ask you to hold out one of your hands with the palm down. The experimenter will then gently but firmly grasp your hand, exerting firm pressure with his thumb on the back of your hand for a few seconds. This leaves a relatively pale patch (the size of the experimenter's thumbprint) on your hand which lasts a few more seconds before fading away. (It is quite easy to demonstrate this effect on yourself, using one hand to grasp the other.) The fading-time will be measured using a stopwatch. This procedure is repeated several times.

It is not always possible to get the pale skin reaction using the method described above, in which case we may sometimes need to use a different technique. That makes use of a blunt instrument (a rubber pencil eraser) to firmly stroke your forearm from a little below the elbow to a little above the wrist. Such action normally leaves a pale streak on the forearm. The streak takes a few seconds to disappear; and the fading-time is again measured using a stopwatch.

EXHIBIT L

DYNAMOMETER

(Instructions to Subjects)

This quick and simple test will measure your grip strength. It is measured using a metal hand grip comprised of two concentric rings (dynamometer). A dial in kilograms is attached to the two rings.

After positioning your fingers in the inner ring, your task is to squeeze the two rings together as hard as you can. You are to use only one hand when gripping the rings and hold the apparatus at your side while applying pressure so you can not read the dial. After squeezing, show the instrument to the experimenter, who will read the dial before resetting it to zero. You repeat this task three times on each hand. (We will start with your dominant hand.)

EXHIBIT M

TRACKING TASK

(Instructions to Subjects)

On the display in front of you is a needle on a dial. You will be told when to begin tracking. The needle will be in the center when the test begins, but will immediately start to wander. You can correct the wandering by means of the foot pedal on your right side.

The object is to keep the needle as close to the central "50" marking on the dial as possible. Pressing the pedal down moves the needle to the right. Releasing the pedal moves the needle to the left. The task is similar to holding a constant speed in an automobile while traveling up and down a rolling roadway.

Your error score will be monitored continuously during each of the experimental periods in which you are asked to track. Your error score will be based not only on the length of time the needle is off the "50" mark, but also on how far the needle is from that mark. Keep the needle as close to the "50" mark as possible all the time. You will be told when the task has been completed.

NOTE: While tracking, you will also be performing a Secondary Task, namely, either the Attentional Selectivity Task (Exhibit N) or the Auditory Vigilance Task (Exhibit O). Your primary task is tracking, but please do not neglect or abandon performance of the other task.

EXHIBIT N

ATTENTIONAL SELECTIVITY TASK

(Instructions to Subjects)

This task is performed at the same time as the Tracking Task. A horizontal array of lights is set up in an arc on each side of the tracking task dial in front of you. Any one of these lights (but never more than one at a time) may light up during the experimental test period. Your task is to cancel the appearance of a light as quickly as possible, using the thumb-button on top of your right hand-grip.

The time you take to cancel each light, and also the number (hopefully none) to which you fail to respond, will be used in scoring your performance. The shorter the time and the fewer lights missed, the better your score. If you fail to respond to any light within a predetermined time it will eventually go out again automatically, but the total burn time will be added to your score.

NOTE: While performing this light-cancelling task, you must also continue to perform the Tracking Task (Exhibit M). Your primary task is tracking, but please do your best to respond to the lights throughout the run. The lights will only come on while you are performing the Tracking Task.

AUDITORY VIGILANCE TEST

(Instructions to Subjects)

This test is performed at the same time as the Tracking Task. Brief musical tones ("beeps") superimposed on a background of hissing noise are heard by you through the head-set. A "beep" appears once every two seconds and is normally a half-second in duration. However, a few "beeps", occurring among the regular-length "beeps" at random intervals ("short beeps"), are somewhat shorter than the regular ones. The "short beeps" last only about four-tenths of a second. Your task is to signal the presence of every "short beep", using the thumb-button on top of your left hand grip. Do not press for regular-length "beeps".

The time you take to signal that a "short beep" is present, and also the number (hopefully none) which you fail to recognize, will be used in scoring. The shorter the time and the fewer signals missed, the better your score. If you (wrongly) signal a regular-length "beep", it will be counted in your total error score.

NOTE: While performing this auditory task, you must also continue to perform the Tracking Task (Exhibit M). Your primary task is tracking, but please do your best to signal "short beeps" throughout the run. You will only hear "beeps" while tracking.

EXHIBIT P

TASK DIFFICULTY ("TD") RATING

(Instructions to Subjects)

You are asked to use a 9-point scale to give your personal rating of the Task Difficulty you experience in performing the main tasks (Tracking and Secondary Tasks) during each run. This rating deals only with how easy or difficult you found the tasks. It should not include judgement of the environmental conditions. You use the same scale whether vibration is present or not. We need one rating at the end of your performance of the Tracking and Secondary Tasks in each experimental condition. As soon as those tasks are completed, you will be asked to announce your "TD Rating". It is important that you make each rating independently. In other words, do your best to treat each rating occasion as a fresh situation without letting your judgement be influenced by any ratings which you may have made earlier, or in other experiments.

Before the experiment begins, please familiarize yourself with the phrases on the 9-point Task Difficulty Rating Scale provided and memorize the corresponding numbers.

TASK DIFFICULTY ("TD") SCALE

1. Extremely Easy
2. Very Easy
3. Easy
4. Not Very Easy
5. Middling
6. Not Very Difficult
7. Difficult
8. Very Difficult
9. Extremely Difficult

EXHIBIT P (Continued)

NOTE: The numbers on this scale do not necessarily correspond with similar numbers on other scales you may use during this experiment.

When you are asked to make "TD" ratings during the experiment, please rate the ease or difficulty with which you performed the tasks in that particular run. We want your immediate impressions. Do not worry about what ratings you may have given before. Using the guidance provided by the nine phrases on the "TD" scale, select the one which best describes your judgement of the ease or difficulty which you were experiencing in that run. The number of the phrase is your "TD Rating". For instance, if you were to decide that the phrase "Easy" best describes your tasks during that run, you would say "TD Number Three"; or if you thought the phrase "Difficult" most appropriate, you would say "TD Number Seven". Please make a firm decision as soon as possible when asked and announce it clearly: only one number can be recorded for any rating (we cannot score afterthoughts). The experimenter will record that number alone as your "TD Rating".

EXHIBIT Q

VISUAL ACUITY (BROKEN RING) TEST

(Instructions to Subjects)

This test is to measure your sharpness of vision (distance eyesight). It is presented during your training runs and during vibration and control runs. It takes about one minute to perform.

You will be told when the "Broken Rings" are about to appear. They are covered by the movable panel labelled "Visual Tests". The cover will be removed, revealing a view (seen through a mirror beyond the enclosure in front of you) of 36 small broken rings. They are printed in black on a white card and look like this:  This one is shown with the "break" to the right ("three o'clock" position).

The rings are arranged in 6 rows of 6 but each ring has the break pointing in a different direction. The directions are identified by the hours of the clock. Here are some examples:

-  "Three o'clock"
-  "Eight o'clock"
-  "Twelve o'clock"

Your task is to read each row as quickly but as accurately as possible, from left to right. Call out the positions in a firm, clear voice. You should identify each row, "Row One", "Row Two" and so on, before calling out the successive clock positions. For example, if the top row looked like this:



your response should be "Row One: six o'clock, one o'clock, nine o'clock, three o'clock, ten o'clock, one o'clock". (It is possible for the same position to occur more than once in the same row; or twice in succession, although this is not common). As soon as you have read Row One, announce "Row Two" and go right on in the same way until you have read all six rows. The test is then ended.

EXHIBIT Q (Continued)

If you cannot be sure of the position of a particular ring, do your best to guess. DO NOT REMAIN SILENT. We score all of your replies, so we must have six answers (even though some may be wrong) for every row of rings presented to you.

It is important that you read out the positions as quickly as you comfortably can, but it is even more important that you do your best to get them right. Remember, if you really cannot be sure of a position, make a guess. Try not to worry overly long about any particular ring. (If your progress is unusually slow, we may have to cut off the display before you have finished all six rows, and only the rings you have managed to complete will be scored.)

EXHIBIT T

MOTION SEVERITY "MS" RATING

(Instructions to Subjects)

You are asked to use a 9-point scale to give your rating of the Motion Severity (degree of gentleness or roughness) of the up-and-down motion (vibration) which you are experiencing at the moment. You will be asked to announce your "MS Rating" near the end of each run. It is important that you make each rating independently. In other words, do your best to treat each occasion on which you are asked to make an "MS" rating as a fresh situation, without letting your judgement be influenced by any ratings which you may have made earlier, or in other experiments.

Before the experiment begins, please familiarize yourself with the phrases on the 9-point Motion Severity Rating Scale provided and memorize the corresponding numbers.

MOTION SEVERITY ("MS") SCALE

1. Extremely Gentle
2. Very Gentle
3. Gentle
4. Not Very Gentle
5. Middling
6. Not Very Rough
7. Rough
8. Very Rough
9. Extremely Rough

NOTE: The numbers on this scale do not necessarily correspond with similar numbers on other scales you may use during this experiment.

EXHIBIT T (Continued)

When you are asked to make a "MS" rating during the experiment, please rate the VIBRATION (up-and-down motion) as it affects you at the moment. We want your immediate impressions. Do not worry about what ratings you may have given before. Using the guidance provided by the nine phrases on the "MS" scale, select the one which best describes your judgement of the vibration which you are experiencing. The number of that phrase is your rating. Please make a firm decision as soon as possible when asked: only one number can be recorded for any rating (we cannot score afterthoughts). When you have made up your mind, call out clearly "MS Number" giving the appropriate number. The experimenter will then record that number as your "MS Rating". For example, if you think that the vibration you are experiencing is "Gentle" during a particular run, you should call out "MS Number Three"; or, if you think the phrase "Very Rough" best describes the vibration, you should say "MS Number Eight".

INCENTIVE PROGRAM
(Instructions to Subjects)

In addition to the regular hourly wage, every Subject will be awarded additional pay in the form of a performance bonus. The purpose of this bonus is to reward Subjects who maintain reasonable alertness and effort on the tracking task and discourage inattentive performance. The size of your bonus will be determined by your tracking error score following each tracking session (15 or 24 minutes). As your tracking accuracy increases the size of your bonus will increase and vice versa. There is no "cut off" tracking score above which you will receive a large bonus or below which you will receive no bonus. Rather, each Subject's tracking score will be compared with a standardized scale to determine bonus size. Bonuses will be awarded following completion of each time series (16 minute, 25 minute, 2-1/2 hour, 4 hour, and 8 hour) of vibration runs.

APPENDIX F

ELECTRONIC TASK SCHEMATICS
(Seat Belt, Tracking, and Hockey Test)

Seat-Belt Tension Monitor

A seat-belt tension monitor package was designed to be used in conjunction with the vibration protocol. The purpose of the monitor package was to assure that each experimental subject was exposed to the same initial seat-belt tension and also to study the decrease or increase in belt tension as a function of vibration exposure time.

The basic package consists of a strain gage sensor, signal conditioner, instrumentation amplifier, and calibrated meter readout. The schematic of the composite package is shown in Figure 1. The sensor consists of four active strain gages connected in a wheatstone bridge configuration. These gages are bonded to an aluminum anchor plate mounted to the side of the vibration seat. The gages are mounted so that when a force is applied to the end point, or belt attachment point of the anchor plate, a bending moment occurs in which two gages are in tension and two are in compression. This bending of the plate and resulting strain gage flexures produces a resistance bridge unbalance which is directly proportional to the applied force. A DC excitation is applied to the bridge so that the voltage output of the bridge is also directly proportional to the applied force.

Since all resistive strain gages are not exactly matched, a signal conditioner is incorporated. This provides the capability of balancing or zeroing out the force sensor under ambient conditions when no load is applied. Also, since the output of the force sensor is in millivolts a differential instrumentation amplifier is used to amplify the bridge output to obtain an output with improved signal to noise ratio. The instrumentation amplifier also provides for selective low pass filtering. For monitoring purposes the output of the instrumentation amplifier drives a DC voltmeter which is calibrated in pounds. Therefore, the result of applying a force through seat-belt tension is a meter deflection which is linearly proportional to the applied load in pounds.

For simplicity of set-up and operation a resistance calibration scheme is employed. This consists of shunting one of the strain gage arms with a calculated resistance value. This produces a bridge unbalance or offset which is analogous

to applying tension to the seat belt. For the particular application, a shunt calibration resistance equivalent to 50 lbs of applied force was used.

Set-up, calibration and operation of the composite package is relatively simple. All cables should be connected as shown in Figure 1 and the system should be allowed to warm-up for a period of 20 minutes. After warm-up, and with no seat belt tension being applied the BALANCE pot should be adjusted so that the meter reads zero pounds. The 50 lb CAL STEP should then be applied using the momentary pushbutton switch, and the SENSITIVITY pot should then be adjusted so that a reading of 50 lbs is obtained on the meter. This is also shown with a red CAL marking on the output meter dial face. The system is now ready to operate and seat belt tension in pounds can be directly set or read from the output meter. If it is desired to experimentally check the overall system calibration a known force can be applied at the belt attachment point using a spring scale or dead weight. The known weight reading can then be checked against the calibrated meter reading.

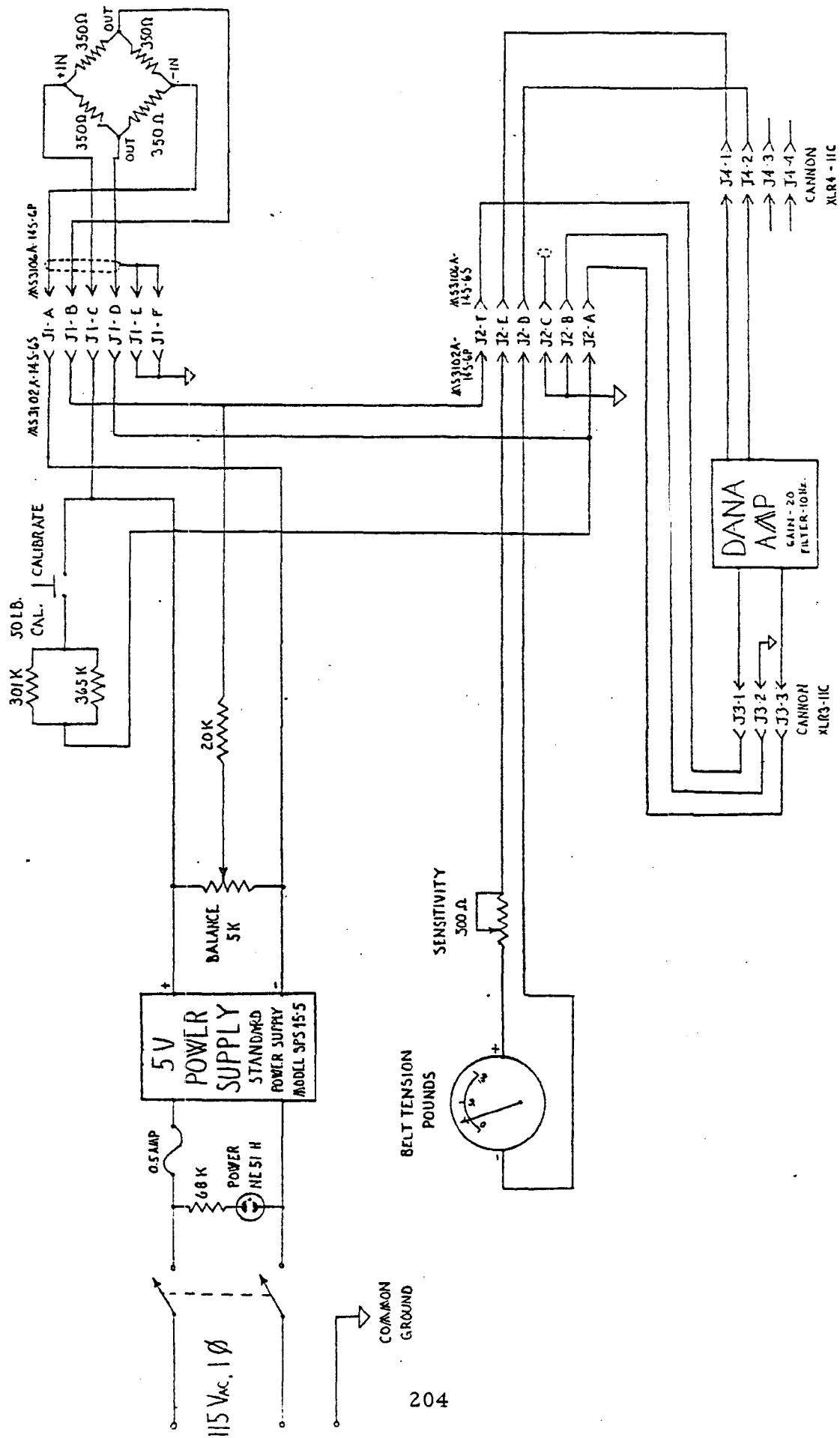
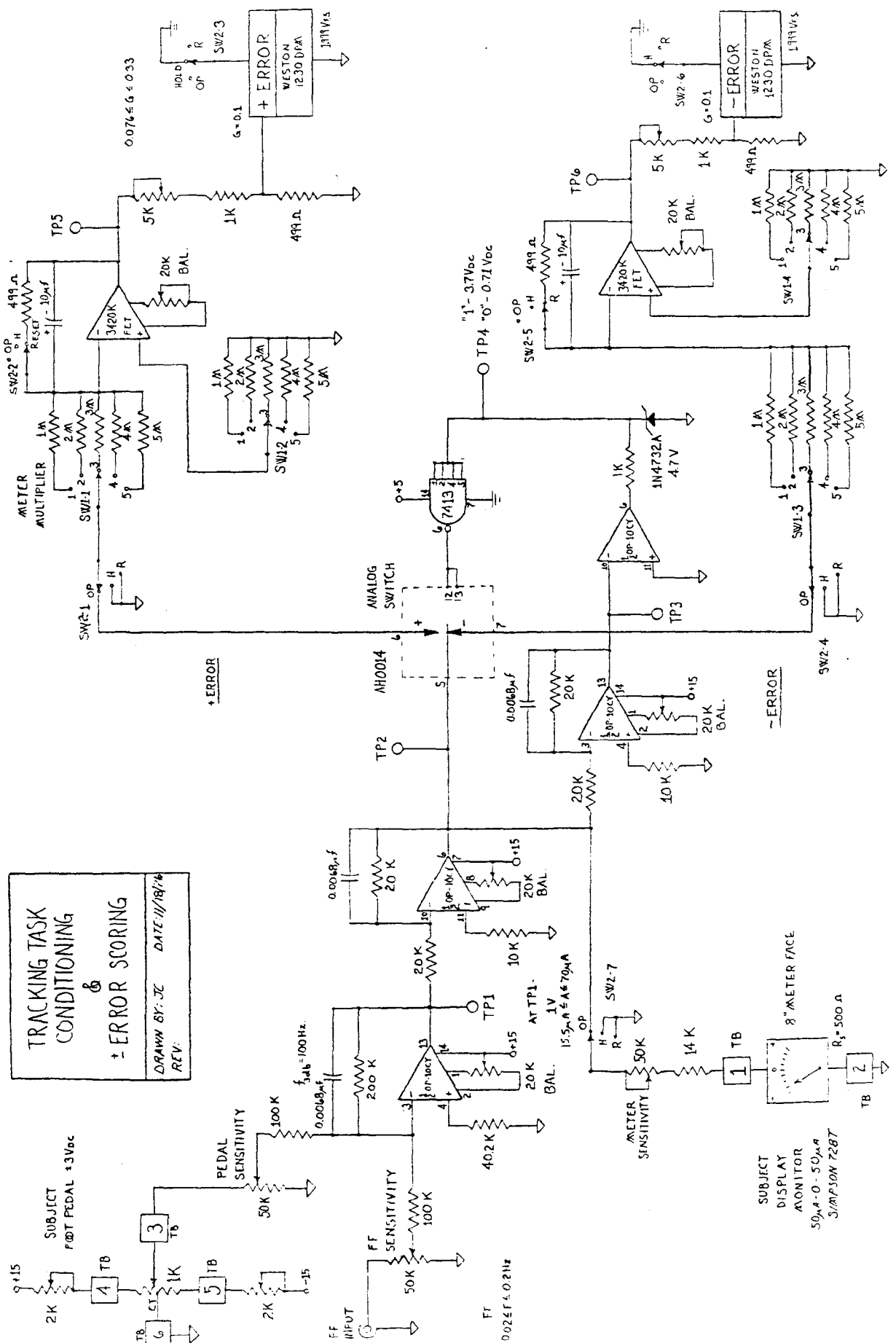


Figure 1. Schematic of Seat Belt Tension Monitor.



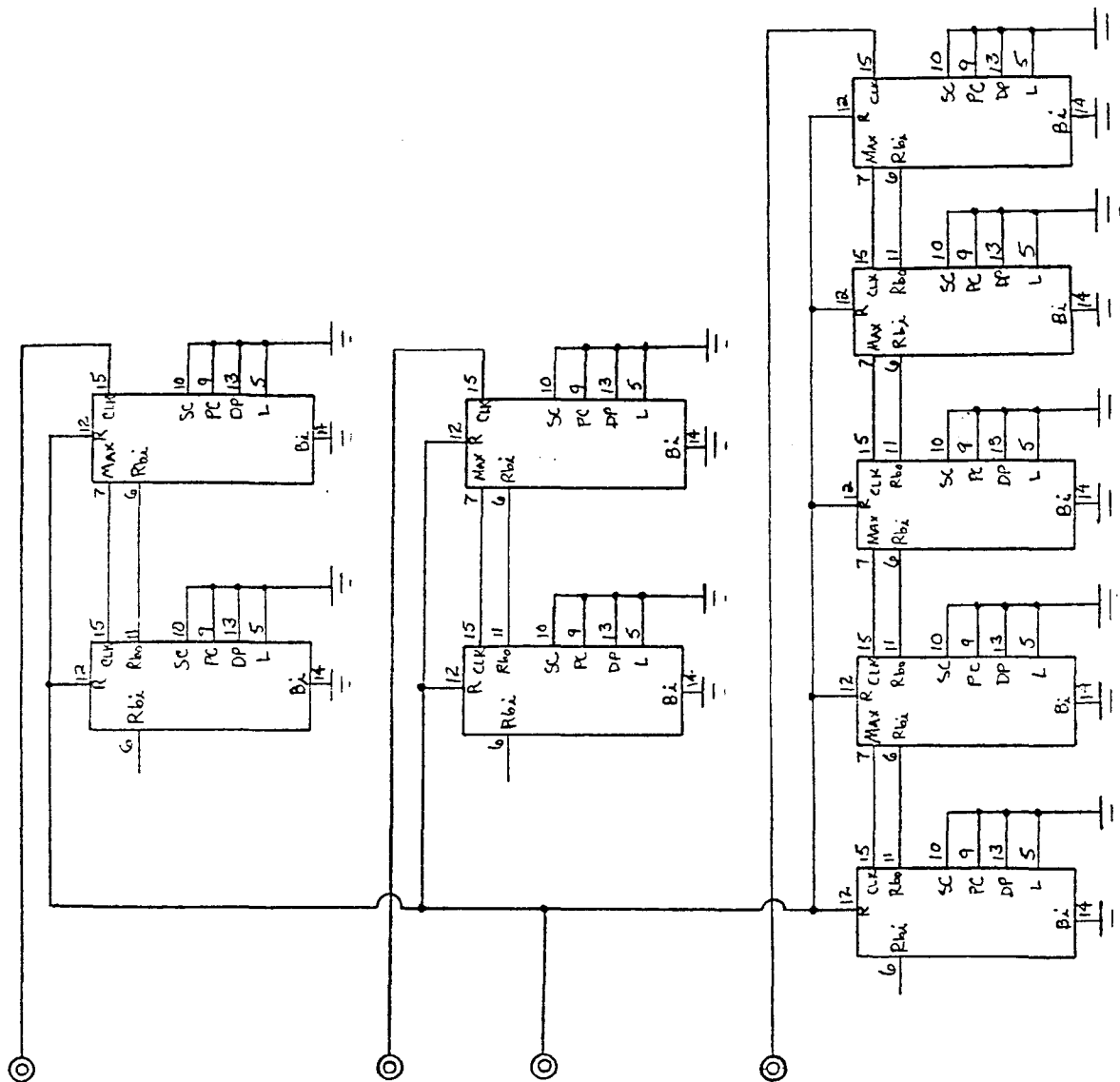
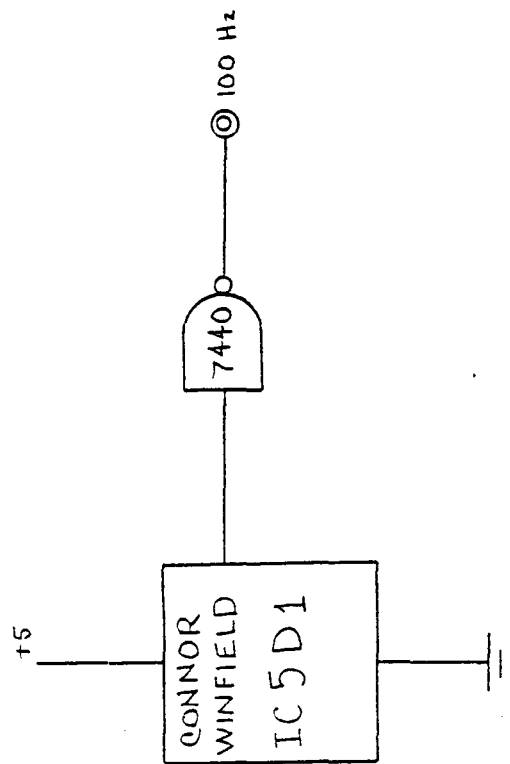
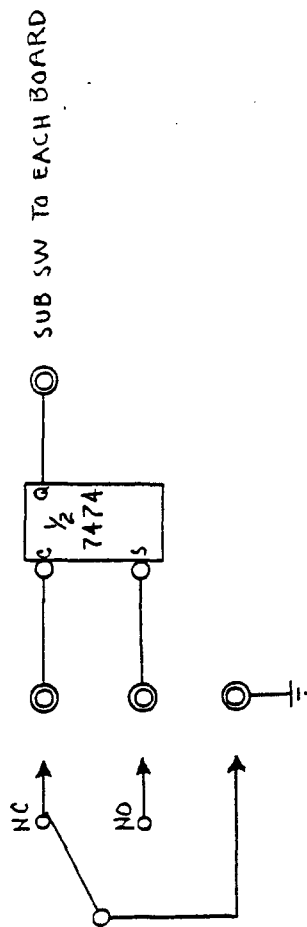
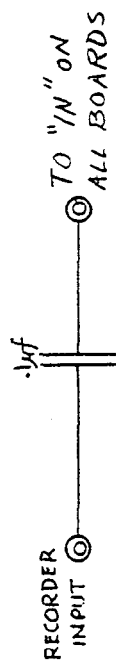


Figure 4. Schematic of the Hockey Light Display Board.



#1 Upper

#2 Lower

Logic and Lamp Board

1. Common
2. +5
3. In 1
4. In 2
5. Time Pot 1
6. Time Pot 1
7. Lamp 2
8. N. C.
9. N. C.
10. N. C.
11. Sub Sw. 1
12. Sub Sw. 2
13. Total Events 1
14. Total Miss 1
15. Lamp 1
16. Clock 1
17. Clock 2
18. 100 Hz IN
19. Total Events 2
20. Total Miss 2
21. Time Pot 2
22. Time Pot 2

Interface and Clock

1. 7474 a To Sub. Sw. on
each board
2. 7474 Reset N.O. Sub. Sw.
3. 7474 Clear N.C. Sub. Sw.
4. N. C.
5. N. C.
6. 100 Hz
7. N. C.
8. +5
9. N. C.
10. N. C.
11. N. C.
12. N. C.
13. N. C.
14. N. C.
15. Gnd. Com
16. N. C.
17. Recorder Input
18. To 'IN' on all boards
19. N. C.
20. N. C.
21. N. C.
22. N. C.

Terminal Board

1. Lamp Common
2. Right 80° 1200 Hz
3. Left 80° 1400 Hz
4. Right 65° 1600 Hz
5. Left 65° 1800 Hz
6. Right 50° 2000 Hz
7. Left 50° 2200 Hz
8. Right 35° 2400 Hz
9. Left 35° 2600 Hz
10. Right 20° 2800 Hz
11. Left 20° 3000
12. N. O. S. W
13. N. C. S. W.
14. Recorder Input

WIRE LIST

<u>NUMBER</u>	<u>FROM</u>	<u>TO</u>
1	IC1-15	Term 2 Total - Miss Upper
2	IC1-7	IC2-15
3	IC3-15	Term 3 Total Events Upper
4	IC3-7	IC4-15
5	IC5-15	Term 4 Clock Upper
6	IC5-7	IC6-15
7	IC6-7	IC7-15
8	IC7-7	IC8-15
9	IC8-7	IC9-15
10	IC10-15	Term 5 Total Miss Lower
11	IC10-7	IC11-15
12	IC12-16	Term 6 Total Events Lower
13	IC12-7	IC13-15
14	IC14-15	Term 7 Clock Lower
15	IC14-7	IC15-15
16	IC15-7	IC16-15
17	IC16-7	IC17-15
18	IC17-7	IC18-15
19	IC1-12	IC2-12
20	IC2-12	IC3-13
21	IC3-12	IC4-12
22	IC4-12	IC9-12
23	IC9-12	IC8-12
24	IC8-12	IC7-12
25	IC7-12	IC6-12
26	IC6-12	IC5-12
27	IC5-12	IC10-12
28	IC10-12	IC11-12
29	IC11-12	IC12-12
30	IC12-12	IC13-12
31	IC13-12	IC18-12
32	IC18-12	IC17-12
33	IC17-12	IC16-12
34	IC16-12	IC15-12
35	IC15-12	IC14-12
36	IC14-12	Term 1 Master Reset

APPENDIX G
VIBRATION MACHINE RUN LOGS

WESTERN GEAR 9" DOUBLE AMPLITUDE SHAKER

Pre-test

1. Clear all equipment from area.
2. Check yokes for proper position (vertical or horizontal).
3. Check all bolts for tightness (table top and yokes).
4. Check oil supply.
5. Turn on air supply and check pressure.
(Sufficient to hold brakes, 80-110 lbs).
6. Turn on water supply (red valve).
7. Turn on 3 breaker on lower left side of power panel,
Circuit breaker 15, 17 and 19.
8. Start generator.

Operation

1. Push start button on lower left of console to start oil pump.
Check oil pressure: White dial - 15 to 30.
Black dial - 25 psi or more.
Oil temperature - No more than 20°F. above ambient.
2. Zero amplitude lamp will light in upper right of console.
3. Switch automatic shutdown system (ASDS) on.
4. Press ASDS Reset-Set Disable.
5. Test brake operation.
6. Switch motor on - check position light.
7. Set frequency at two (2) CPS to start shaft.
8. Set frequency to 4 Hz.
9. Set rise time clock according to chart for .4 G/pk (RT = 16.7 sec).
10. Start amplitude clock to insert amplitude.

Atch 2

11. After clock stops, return dial to zero.
12. At the 0.4 G level, adjust ASDS level-set slowly until Chan. 1 dump lamp lights. Dial should read . This test assures that the accelerometer is operating properly.
13. Depress Decrease button.
14. Switch motor off.
15. ASDS must now be switched to enable for the duration of the test.
16. Set ASDS level set Chan. 1 to the desired point on the micrometer dial.
17. Subject can now board device.
18. Depress clock button (amber light will light, green Zero amplitude light will go out).
19. After clock stops, return dial to zero.
20. Have right hand on or next to decrease button.
21. When desired G-level is reached, amber light will go out.

Emergency Shutdown

1. Depress and hold red brake button (EMERGENCY STOP ONLY), and switch motor off.

Normal Shutdown

1. Depress decrease button. Wait for zero light, if next level is different, reset ASDS to new desired dump point, continue test or continue to next step.
2. Move right hand to turn motor switch off.
3. Push stop button lower left of console.
4. Only depress and hold Emergency Brake when displacement and amplitude are hindering subject. Shut off Motor, Generator, Circuit Breaker 15, 17 and 19, Water, Air.

Special Instructions

1. To increase amplitude, depress increase button.
2. To level increase, depress and release jog decrease button.
3. To determine G-level, start stop watch when decrease is pushed - Time until green Zero amplitude light comes on.

4. Check stop watch time against rise time chart.

5. After runs with input amplitude of less than 3 seconds - Stop the machine rotation. Insert 5 sec amplitude. Depress decrease amplitude button to be assured that the machine is truly at zero amplitude.

NOTE: ASDS should be set at a dial reading 25% above the desired intensity level.

Experiment UDRI (NIOSH)-1-ROL-OH-00479-01

Sheet 01

VIBRATION MACHINE RUNNING LOG

Mode Vertical

UDRI RUN #	DATE	T I M E			FREQU (Hz)	ACCEL (g _{max})	FIXED EQUIPMENT	SUBJECT	S#	Tot LOAD (lbs)	OPER- ATOR	OCCURRENCES/ REMARKS
		Power on	Power Off	Start Run	Stop Run							
001	13 Nov 74	2:15	2:30	2:20	2:55	.8	SEAT	200 Dummy		287.5	AR	For duty Com.
002	13 Nov 74	2:35	2:50	2:30	3:07	.8	SEAT	200 Dummy		287.5	AR	Try out Spectro
003	13 Nov 74	3:50	3:56	3:53	4:00	.8	SEAT	200 Dummy		287.5	AR	Training
004	14 Nov 74	2:15	2:30	2:20	2:59	.8	SEAT	200 Dummy		287.5	AR	1-10-74
005	14 Nov 74	3:05	3:10	3:07	3:09	.6	SEAT	200 Dummy		287.5	AR	1-6-74
006	14 Nov 74	3:55	4:01	3:56	4:00	.6	SEAT	200 Dummy		287.5	AR	1-3-74
007	15 Nov 74	11:00	11:30	11:05	11:29	.8, .6, .6	SEAT	200 Dummy		287.5	AR	Training
008	29 Nov 74	8:00	8:05	8:05	8:35	.43, .3, .3	SEAT	200 Dummy		287.5	AR	3-5-74
009	5 Feb 75	10:30	10:45	10:35	10:43	.18, .4, .4	SEAT	200 Dummy		287.5	AR	1-7-74
010	6 Feb 75	9:30	9:55	9:35	9:50	.18, .13, .13	SEAT	200 Dummy		287.5	AR	2-5-74
011	11 Feb 75	9:45	10:25	9:55	10:10	.14	SEAT	200 Dummy		287.5	AR	1-5-74
012	12 Feb 75	9:05	10:05	9:55	10:10	.14	SEAT	200 Dummy		287.5	AR	1-5-74
013	12 Feb 75	2:05	2:15	2:05	2:10	.18, .13, .13	SEAT	200 Dummy		287.5	AR	1-5-74
014	13 Feb 75	12:30	3:05	1:30	1:46	.4	SEAT	200 Dummy		287.5	AR	1-5-74
015	18 Feb 75	9:05	10:30	9:30	9:40	.43	SEAT	200 Dummy		287.5	AR	1-5-74
016	19 Feb 75	10:05	10:45	10:15	10:40	.18, .13, .13	SEAT	200 Dummy		287.5	AR	1-5-74
017	19 Feb 75	1:05	4:05	1:30	1:46	.3	SEAT	200 Dummy		287.5	AR	1-5-74
018	19 Feb 75	1:00	4:05	3:30	3:46	.3	SEAT	200 Dummy		287.5	AR	1-5-74
019	20 Feb 75	8:05	11:30	8:40	9:01	.3	SEAT	200 Dummy		287.5	AR	1-5-74
020	20 Feb 75	8:05	11:30	11:05	11:21	.3	SEAT	200 Dummy		287.5	AR	1-5-74

Total Runs This Sheet 20 Runs
 Total Hours This Sheet 4 Running Hours
 Cumulative Running Time _____ Running Hours

USAF/AMRL Inspection/Maintenance Requested
 USAF/AMRL Inspection Maintenance Performed
 Work Done

19
19

Sheet 02Western Gear

VIBRATION MACHINE RUNNING LOG

Mode Vert

UDRI RUN #	DATE	T I M E		FREQU (Hz)	ACCEL (g _{max})	FIXED EQUIPMENT	SUBJECT	S#	Tot LOAD (lbs)	OPER- ATOR	OCCURRENCES/ REMARKS
		Power on	Power Off	Start Run	Stop Run						
021	20 Feb 75	1:15	3:00	1:53	2:09		Spitz	05	180+		1-3-16
022	21 Feb "	10:00	12:00	11:00	11:16		Pinnaro	06	162+		1-7-16
023	21 Feb "	3:00	4:30	3:35	3:56		Cummings	03	150+		2-5-16
024	24 Feb "	8:45	12:00	9:15	9:31		Pinnaro	09	162+		2-1-16
025	24 Feb "	8:45	12:00	11:00	11:16		Cummings	08	145+		2-5-16
026	25 Feb "	8:00	4:30	8:35	8:51		Cummings	09	155+		3-7-16
027	25 Feb "	8:00	4:30	10:30	10:46		Kosser	08	145+		2-1-16
028	25 Feb "	8:00	4:30	—	—		Crawford	10	195+		training
029	25 Feb "	8:00	4:30	3:20	3:36		Crawford	09	145+		2-5-16
030	26 Feb	8:30	12:00	—	—		Pinnaro	1	—		training
031	26 Feb	8:30	12:00	10:30	10:46		Pinnaro	06	162		3-3-16
032	26 Feb	1:00	4:30	—	—		Wright	02	145		training
033	26 Feb	1:00	4:30	3:15	3:26		Cummings	03	150		3-3-16
034	27 Feb	8:15	12:00	8:36	8:52		Cummings	09	155		4-1-16
035	27 Feb	8:15	12:00	10:25	10:41		Kosser	08	145		3-1-16
036	27 Feb	1:15	3:15	1:30	1:46		Spitz	05	180		2-1-16
037	28 Feb	8:15	12:00	9:30	9:46		Pinnaro	08	145		4-3-16
038	28 Feb	8:00	12:00	11:00	11:16		Pinnaro	06	162		4-5-16
039	28 Feb	1:15	4:15	1:22	1:39		Friedberg	04	145		1-1-25
040	28 Feb	1:15	4:15	3:15	3:31		Cummings	03	150		4-1-16

Total Runs This Sheet Runs 19
 Total Hours This Sheet 4.5 Running Hours 19
 Cumulative Running Time 8.5 Running Hours 19
 Work Done

Western Gear

VIBRATION MACHINE RUNNING LOG

Mode V

UDRI RUN #	DATE	T I M E			FREQU (Hz)	ACCEL (g _{max})	FIXED EQUIPMENT	SUBJECT	S#	Tot LOAD (lbs)	OPER- ATOR	OCCURRENCES/ REMARKS
		Power on	Power Off	Start Run	Stop Run							
0411	3 March 75	8:15	12:00					R-12 under	01			Training
0412	3 March	8:15	12:00	11:00	11:25	.26		Dimension	06	162+		1-7-25
0413	3 March	1:15	4:30	1:30	1:45	.36		Fuller log	04	165+		2-3-25
0414	4 Mar	8:00	12:30	8:45	9:10	.36		Gardner	09	155		1-3-25
0415	4 Mar	8:00	12:30	10:45	12:10	.26		Roller	08	145		1-5-25
0416	4 Mar							Crabman	10	195		Training
0417	6 March	9:15	12:30	8:45	9:10	.26		Gardner	09	155		2-5-25
0418	6 March	8:15	12:30	10:45	12:10	.26		Roller	08	145		1-7-25
0419	6 March	1:15	4:30	1:40	1:56	.30		Crabman	10	195		1-5-16
0500	6 March	1:15	4:30	3:20	3:36	.30		Crabman	09	145		3-5-16
0501	7 March	10:30	3:30	10:35	2:35	.05		Crabman	01	163		1-5-2000
0502	9 March 75	8:00	11:00	8:50	9:15	.26		R-12 under	09	155		Added -
0503	11 Mar 75	12:30	3:00	1:30	1:46	.30		Gardner	09	155		3-7-16
0504	11 Mar 75	10:00	12:00	10:48	11:12	.0		Spur	05	162		7-1-25
0505	12 Mar 75	1:00	4:30	1:30	1:56	.26		Dimension	06	165		3-3-25
0506	12 Mar	1:00	4:30	2:30	2:56	.26		Fuller log	04	14		2-5-25
0507	13 Mar	8:00	12:00	8:45	9:10	.26		Crabman	09	14		3-7-25
0508	13 Mar	8:00	12:00	10:30	10:55	.36		Gardner	09	14		Added
0509	13 Mar	1:00	4:30	1:10	1:35	.36		Roller	01	14		2-3-26
0510	13 Mar	1:00	4:30	2:00	2:25	.36		Crabman	10	14		Added

Total Runs This Sheet 48

Total Hours This Sheet 48 Running Hours

Cumulative Running Time 1748 Running Hours

USAF/AMRL Inspection/Maintenance Requested 19

USAF/AMRL Inspection Maintenance Performed 19

Work Done

Experiment UDRI (NIOSH) -1-ROL-OH-00479-01

Sheet 04

VIBRATION MACHINE RUNNING LOG

Mode VWestern gear

UDRI RUN #	DATE	T I M E		FREQU (Hz)	ACCEL (g _{max})	FIXED EQUIPMENT	SUBJECT	S#	Tot LOAD (lbs)	OPER-ATOR	OCCURRENCES/REMARKS
		Power on	Power Off	Start Run	Stop Run						
061	17 Mar 75	10:00	12:00	10:15	10:31		Donaghan	03			4-3-16
062	17 Mar 75	1:30	3:30	1:45	2:06		Cunningham	03			3-3-75
063	18 Mar 75	8:00	12:00	8:35	8:56		Gardner	09			4-1-25
064	18 Mar 75	8:00	12:00	10:05	11:00		Rossini	08			3-1-25
065	18 Mar 75	8:00	12:00	12:40	12:56		Cushman	10			3-1-16
066	18 Mar "	1:05	3:45	2:50	3:06		Spencer	05			4-5-16
067	19 Mar "	9:05	12:00	9:30	10:55		Cunningham	07			1-1-76
068	19 Mar "	1:05	4:30	1:40	2:05		Fullback	04			4-1-76
069	20 Mar	1:00	4:30	3:00	3:25		Cunningham	03			4-1-75
070	20 Mar	8:05	12:05	9:05	9:25		Rossini	06			3-3-25
071	20 Mar	8:05	12:05	10:30	10:55		Cushman	08			4-3-25
072	20 Mar	1:00	4:30	1:20	10:36		Spencer	10			4-7-16
073	20 Mar	1:00	4:30	3:00	3:25		Cunningham	05			1-3-25
074	24 Mar	10:05	12:05	10:30	10:55		Cushman	07			2-7-25
075	24 Mar	1:05	3:30	2:35	3:00		Cushman	10			1-5-25
076	25 Mar	1:05	4:30	1:05	1:30		Cushman	10			2-2-25
077	25 Mar	1:05	4:30	2:40	3:05		Cushman	07			3-5-25
078	27 "	1:05	4:30	1:30	4:05		Cushman	04			1-1-150
079	1 April	1:05	4:30	1:15	1:40		Cushman	10			3-1-25
080	1 April	1:00	4:30	1:30	2:45		Spencer	15			2-1-25

Total Runs This Sheet RunsTotal Hours This Sheet 7.6 Running HoursCumulative Running Time 2558 Running HoursUSAF/AMRL Inspection/Maintenance Requested 19USAF/AMRL Inspection Maintenance Performed 19

Work Done

WESTERN Gear VIBRATION MACHINE RUNNING LOGMode V

UDRI RUN #	DATE	T I M E			FREQU (Hz)	ACCEL (g _{max})	FIXED EQUIPMENT	SUBJECT	S#	Tot LOAD (lbs)	OPER- ATOR	OCCURRENCES/ REMARKS
		Power on	Power Off	Start Run	Stop Run							
81	April 2	8:00	12:00	8:45	11:15	2		Confirmation				1-3-150 (120)
82	April 2	1:00	4:00	1:15	1:40	0		Calibration	10			3-1-25
83	April 2	1:00	4:00	2:00	2:25	8		Spin				3-7-25
84	April 3	8:30	12:00	10:45	11:10	4		Spin	16			
85	April 3	1:00	4:30	1:30	4:00	2		Full Run				
86	April 7	8:00	12:00	9:15	11:45	2		Spin	01			1-3-150
87	April 7	1:00	4:30	1:30	4:00	4	Appt	Spin				1-3-150
88	April 8	2:00	4:00	2:15	2:40	4		Calibration	10			4-5-25
89	April 10	9:00	12:00	10:45	11:10	8		Spin	10			1-7-25
90	April 10	12:30	4:30	1:30	4:00	4		Calibration	6			1-5-150
91	April 14	1:00	4:30	1:30	4:00	4		Full Run	24			3-5-150
92	April 14	1:00	4:30	1:30	4:00	0		Spin	26			2-1-150
93	April 17	"	"	"	"	2		"	26			3-3-150

Total Runs This Sheet _____
 Total Hours This Sheet 22.4 Running Hours
 Cumulative Running Time 48.18 Running Hours

USAF/AMRL Inspection/Maintenance Requested _____
 USAF/AMRL Inspection Maintenance Performed _____
 Work Done _____

Wetzel

VIBRATION MACHINE RUNNING LOG

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER/ time
		Power on	Power off	Meter on	Meter off				
01	June 19	—	—	1459.8	—	0	.000	Swick #12	TRAINING
02	June 19	—	—	—	—	0	.000	BAB #12	11
03	June 24	—	—	—	—	0	.000	McDOW	11
04	June 27	8:30	12:00	1459.8	1459.9	2.4	.144	BAB #12	11
05	June 30	8:30	12:00	1459.9	1459.9	0	.000	BAB #12	11
06	July 2	8:30	12:00	1459.9	1461.5	2	.144	Swick	11
07	July 3	8:30	9:30	—	—	—	—	CANCEL	11
08	July 11	—	—	—	—	—	—	Miller #14	11
09	July 15	—	—	—	—	—	—	Miller #11	11
10	July 16	12:45	3:30	1459.5	1463.0	2.4	.144	Miller #14	11

TOTAL RUNS THIS SHEET 10 RunsTOTAL HOURS THIS SHEET 3.3 Running hoursTOTAL CUMULATIVE RUNNING TIME 3.3

Maintenance Problems

Sheet 02Mode V

VIBRATION MACHINE RUNNING LOG

Western Gear

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
11	July 21	8:15	9:45	—	—	—	—	Miller #14	Cancel
12	July 24	8:15	9:45	1463	1463.3	4	.102	NINE	EQUIP. CHECK
13	July 22	—	—	—	—	—	—	Schalnot #16	TRAINING
14	July 24	12:30	4:08	14633	1464.4	2, 4	.144	Itaiozer #15	TRAINING
15	July 25	—	—	—	—	—	—	RUPD #17	"
16	July 28	8:30	12:15	1464.4	1467.1	4	.102	BAB #12	1-4-150
17	July 29	8:30	10:55	1467.1	1468.2	2	.144	Schalnot #16	TRAINING
18	July 30	8:15	12:05	1468.2	1470.8	2	.144	BAB #12	2-2-150
19	July 31	—	—	—	—	—	—	Brewer #19	TRAINING
20	Aug 1	7:50	11:50	1470.8	1473.3	0	.000	BAB #12	3-0-150

TOTAL RUNS THIS SHEET 20 RunsTOTAL HOURS THIS SHEET 10.3 Running hoursTOTAL CUMULATIVE RUNNING TIME 13.6

Running hours

Maintenance Problems

low

Sheet

03

Mode

✓

Western Geop

VIBRATION MACHINE RUNNING LOG

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
21	Aug. 1 1975	7:50	4:00	1473.3	1474.3	2	.144	FAY #18	Training
22	Aug 4	7:40	4:10	1474.3	1478.4	4	.076	BAND #12	1-4-240
23	Aug. 4	7:40	4:10	1478.4	1480.9	2	.144	HANSEN #15	1-2-150
24	Aug 5	12:45	1:30	1480.9	1481.0	4	.400	—	Equip. Check
25	Aug 6	12:30	4:30	1481.0	1483.5	0	.000	HANSEN #15	2-0-150
26	Aug 7	12:50	4:20	1483.5	1484.7	4	.102	REP #17	2-2 Training
27	Aug 7	12:30	4:00	1484.7	1487.2	4	.102	HANSEN #16	3-4-150
28	Aug. 11	7:20	1:00	1487.2	1491.6	2	.100	HANSEN #15	1-2-240
29	Aug. 11	—	—	—	—	—	—	HANSEN #20	1st training
30	Aug 12	7:00	10:50	1491.6	1492.7	4	.110	HANSEN #11	2-0-150

TOTAL RUNS THIS SHEET 5 Runs

TOTAL HOURS THIS SHEET 1.4 Running hours

TOTAL CUMULATIVE RUNNING TIME 33

Running hours

Maintenance Problems

2.0

Sheet 04

VIBRATION MACHINE RUNNING LOG

Weston #93

Mode V

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
31	AUG. 13	7:15	12:30	1492.1	1496.3	0	.000	HAINZER #15	2-0-240
32	AUG 13	2:30	5:15	1492.3	1497.3	4	.102	Nelson #20	2nd Training
33	AUG 14	7:30	12:55	1497.3	1501.5	2	.108	SANCS #12	2-2-240
34	AUG 15	7:45 AM	7:45 PM	1501.5	1505.7	4	.016	HAINZER #15	3-4-240
35	AUG 15	7:45 AM	7:45 PM	1505.7	1508.2	0	.000	Rudd #17	1-0-150
36	AUG 15	7:45 AM	7:45 PM	1508.2	1510.75	2	.144	FAY #18	1-2-150
37	AUG 18	7:45 AM	4:50 PM	1510.75	1511.9	4	.102	BREWER #19	2ND TRAINING
38	AUG. 18	7:45 AM	4:50 PM	1511.9	1514.4	4	.102	FAY #18	2-4-150
39	AUG. 19	12:35 PM	4:10 PM	1514.4	1517.0	2	.144	Rudd #17	2-2-150
40	AUG. 20	7:30 AM	5:45	1517.0	1525.3	2	.065	HAINZER #15	1-2-480

TOTAL RUNS THIS SHEET 8

Runs

TOTAL HOURS THIS SHEET 32.6

Running hours

TOTAL CUMULATIVE RUNNING TIME 65.6

Running hours

Maintenance Problems

None

Sheet 05

VIBRATION MACHINE RUNNING LOG

Wester #93

Mode V

UDRI RUN	DATE	TIME				FREQ. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
41	AUG 21	7:30 AM	11:22 AM	1525.3	1526.99	4	.102	Brewer #19	1-4-150
42	AUG 21	1:00 PM	4:05 PM	1526.99	1530.5	4	.102	Rood #17	3-4-150
43	AUG 22	7:30 AM	4:30 PM	1530.5	1534.55	0	.000	BAB #12	3-0-240
44	AUG 22	7:30 AM	4:30 PM	1534.55	1537.5	0	.000	FAY #18	3-0-150
45	AUG 25	7:35 AM	5:55 PM	1537.5	1539.6	0	.000	Brewer #19	2-0-150
46	AUG 25	7:35 AM	5:55 PM	1539.6	1543.7	2	.108	FAY #18	1-2-240
47	AUG 26	7:25 AM	5:40 PM	1543.7	1551.75	0	.000	HAINZER #15	2-0-480
48	AUG 27	8:30	5:50	1551.75	1554.3	2	.144	Brewer #19	3-2-150
49	AUG 27	8:30	5:50	1554.3	1558.3	0	.000	Rood #17	1-0-240
50	AUG 28	7:45	6:05	1558.3	1560.9	0	.000	Achor #11	1-0-150

TOTAL RUNS THIS SHEET 10 RunsTOTAL HOURS THIS SHEET 37.6 Running hoursTOTAL CUMULATIVE RUNNING TIME 103.2

Running hours Maintenance Problems

Sheet 06Mode V

Notes F193

VIBRATION MACHINE RUNNING LOG

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
51	Aug. 28 1975	7:45 AM	6:45 PM	1560.9	1564.9	4	.076	FAY #18	2-4-240
52	Aug 29	7:39 AM	1:45 PM	1564.9	1569.1	4	.045	HAINZER #15	ABORT 3-4-480
53	2 Sept	7:55 AM	5:50 PM	1569.1	1577.2	4	.045	HAINZER #15	3-4-480
54	3 Sept	7:55 AM	6:10 PM	1577.2	1579.9	2	.144	Achor #11	2-2-150
55	3 Sept	7:55 AM	6:10 PM	1579.9	1583.9	2	.108	Rudd #17	2-2-240
56	4 Sept	7:50 AM	6:10 PM	1583.9	1588.1	4	.076	BREWER #19	1-4-240
57	4 Sept	7:50 AM	6:10 PM	1588.1	1592.0	0	.000	FAY #18	3-0-240
58	5 Sept.	8:10 AM	5:55 PM	1592.0	1594.6	4	.102	Achor #11	3-4-150
59	5 Sept.	8:10 AM	5:55 PM	1594.6	1598.7	4	.076	Rudd #17	3-4-240
60	8 Sept	7:50 AM	1:05 PM	1598.7	1602.7	0	.000	BREWER #19	2-0-240

TOTAL RUNS THIS SHEET 10 Runs TOTAL HOURS THIS SHEET 41.8 Running hoursTOTAL CUMULATIVE RUNNING TIME 145.0 Running hours Maintenance Problems None

Western Gear Bldg #93 VIBRATION MACHINE RUNNING LOG

Sheet

67

Mode

Vertical

UDRI RUN	DATE	TIME				FREQ. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
61	9 Sept	7:45 AM	6:00 PM	1602.7	1611.1	2	.065	FAY #18	1-2-480
62	10 Sept	7:45 AM	6:05 PM	1611.1	1615.2	2	.108	BREWER #19	3-2-240
63	10 Sept	7:45 AM	6:05 PM	1615.2	1619.1	0	.000	Achore #11	1-0-240
64	11 Sept	7:40 AM	6:05 PM	1619.1	1627.3	4	.045	BAA B #12	1-4-480
65	12 Sept	11:35 AM	5:05 PM	1627.3	1631.6	2	.108	Achore #11	2-2-240
66	15 Sept	10:45 AM	11:35 AM	1631.6	1632.2	2+4	.108+102	Achore #11	Run CANCELLED
67	16 Sept	7:50 AM	6:22 PM	1632.2	1640.35	4	.045	FAY #18	2-4-480
68	17 Sept	7:35 AM	5:25 PM	1640.35	1648.5	0	.000	Rudd #17	1-0-480
69	18 Sept	8:00 AM	6:00 PM	1648.5	1656.7	4	.015	BREWER #19	1-1-480
70	22 Sept	11:30 AM	5:00 PM	1656.7	1660.8	4	.076	Achore #11	3-4-240

TOTAL RUNS THIS SHEET 7 Runs

TOTAL HOURS THIS SHEET 58.1 Running hours

TOTAL CUMULATIVE RUNNING TIME 203.1

Running hours Maintenance Problems

VIBRATION MACHINE RUNNING LOG

Mode VERTICALWESTERN GEAR Bldg #3

UDRI RUN	DATE	TIME				FREQ. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
171	23 Sept 1975	8:15 AM	4:40 PM	1660.8	1660.8	0	.000	D. MARCO #6	TRAINING
172	23 Sept	8:15 AM	4:40 PM	1660.8	1663.3	0	.000	NELSON #20	1-0-150
173	25 Sept	7:45 AM	4:15 PM	1663.3	1666.3	2	.144	D. MARCO #6	1-2-150
174	25 Sept	7:45 AM	4:15 PM	1666.3	1668.8	4	.102	NELSON #20	2-4-150
175	26 Sept	8:00 AM	6:00 PM	1668.8	1677.0	2	.065	Rudd #17	2-2-480
176	29 Sept	7:45 AM	6:05 PM	1677.0	1685.7	0	.000	Achor #11	1-0-480
177	30 Sept	12:15 PM	4:10 PM	1685.7	1688.3	2	.144	NELSON #20	3-2-150
178	1 Oct	7:55 AM	8:25 AM	1688.3	1688.3	0	.000	ENTER-UPPER #19	Run CANCELLED
179	2 Oct	7:55 AM	12:00 PM	1688.3	1691.1	4	.102	D. MARCO #6	2-4-150
80	3 Oct	7:50 AM	6:00 PM	1691.1	1699.3	0	.000	FAY #18	3-0-480

TOTAL RUNS THIS SHEET 8 RunsTOTAL HOURS THIS SHEET 38.5 Running hoursTOTAL CUMULATIVE RUNNING TIME 241.6

Running hours

Maintenance Problems 3 Oct - MACHINE11 MIN RUNS IN SEQUENCE - CALLED!

Sheet 09Western Gear Bldg 93 VIBRATION MACHINE RUNNING LOGMode Vertical

UDRI RUN	DATE	TIME				FREQ. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
81	6 Oct.	12:20 PM	4:45 PM	1699.3	1703.25	0	.000	NE/SON #20	1-0-240
82	7 Oct.	7:50 AM	11:30 AM	1703.25	1705.8	0	.000	D. MARCO #6	3-0-150
83	8 Oct.	11:35 AM	5:00 PM	1705.8	1710.1	4	.076	NE/SON #20	2-4-240
84	9 Oct.	7:40 AM	6:00 PM	1710.1	1718.1	0	.000	BREWER #19	2-0-480
85	10 Oct.	8:00 AM	6:20 PM	1718.1	1726.2	4	.045	Rudd #17	3-4-480
86	14 Oct.	7:35 AM	6:00 PM	1726.2	1734.3	2	.065	Achor #11	2-2-480
87	15 Oct.	11:00 AM	6:05 PM	1734.3	1738.1	2	.108	NE/SON #20	3-2-240
88	16 Oct.	1:00 PM	6:10 PM	1738.1	1742.45	2	.108	D. MARCO #6	1-2-240
89	17 Oct.	7:40 AM	6:10 PM	1742.45	1750.6	2	.065	BAB #12	2-2-180
90	20 Oct.	7:30	5:16	1750.6	1758.5	0	.000	BAB #12	3-0-480

TOTAL RUNS THIS SHEET 10 RunsTOTAL HOURS THIS SHEET 59.2 Running hoursTOTAL CUMULATIVE RUNNING TIME 300.8Running hours Maintenance Problems NONE

VIBRATION MACHINE RUNNING LOG

Mode

Vertical

UDRI RUN	DATE	T I M E				FREQU. (Hz)	ACCEL g(max)	SUBJECT	RUN NUMBER
		Power on	Power off	Meter on	Meter off				
91	21 Oct 1975	1:15pm	6:30pm	1758.5	1762.6	4	.076	D. Harco #06	2-4-240
92	22 Oct.	7:50am	5:45pm	1762.6	1790.6	0	.000	Nelson #20	1-0-480
93	24 Oct	12:55am	6:30pm	1770.6	1774.6	0	.000	D. Harco #06	3-0-240
94	28 Oct	7:15am	5:05pm	1794.6	1782.7	2	.065	D. Harco #06	1-2-480
95	3 Nov.	7:35am	5:40pm	1782.7	1790.85	4	.045	Nelson #20	2-4-480
96	4 Nov.	7:10am	9:20pm	1790.85	1792.1	4	.045	D. Harco #06	Run Aborted 2-4-480
97	6 Nov.	7:30am	5:10pm	1792.1	1800.2	4	.045	D. Harco #06	2-4-480
98	10 Nov.	7:25am	5:40pm	1800.2	1808.3	2	.065	Nelson #20	3-2-480
99	11 Nov.	7:30am	6:00pm	1808.3	1816.45	2	.065	Brewer #19	3-2-480
100	13 Nov.	7:10am	5:10pm	1816.45	1824.5	0	.000	P. Harco #06	3-0-480

TOTAL RUNS THIS SHEET

9

Runs

TOTAL HOURS THIS SHEET

66

Running hours

TOTAL CUMULATIVE RUNNING TIME

366.8

Running hours

Maintenance Problems

None

Sheet 11

Western Gear

Bb/s 93

VIBRATION MACHINE RUNNING LOG

Mode

Vertical[illegible]

TOTAL RUNS THIS SHEET	<u>1</u>	Runs		TOTAL HOURS THIS SHEET	<u>8.8</u>	Running hours
TOTAL CUMULATIVE RUNNING TIME	<u>375.8</u>			Running hours		Maintenance Problems
						<u>NONE</u>

4 February 1976

OPERATOR CHECKLIST
C-5 Electrodynamic Shaker
(with air suspension)

1. With table empty, check the clearance at each air support. The clearance must be 3 inches. Adjust if needed.
2. Check that all hardware is secure and all grounds are connected.
3. Turn Filament, Field, Plate, and Amplitude controls counter-clockwise to stop.
4. Plug 220 VAC and 120 VAC connector in the appropriate receptacle on the wall.
5. Switch 220 VAC fuse box "ON". Switch 120 VAC "ON". (CB-39)
6. Press the "Start" button. (Pilot light indicates system is ON) Switch "ON" oscillator and Automatic Shutdown system.
7. Advance the "Filament Voltage" control slowly to 7.5 V.
8. After 60 seconds, the plate time delay will close. (A loud "click" is audible.) Advance the "Plate Voltage" control slowly until a slight dip in the plate voltage occurs. (At approx. 3KV.)
9. Wait 15 seconds or until "Screen Voltage" energizes and indicates approximately 900 volts.
10. Advance "Plate Voltage" to 5KV.
11. Check the Amplitude Overtravel Interlocks:
 - a) Trip the lower overtravel switch. This must remove plate voltage. Reset switch. Turn the "Plate Voltage" control full counter-clockwise to reset the circuit. Restore plate voltage as detailed in stage 8.
 - b) Trip the upper overtravel interlock. This must remove plate voltage. Reset switch. Turn the "Plate Voltage" control full counter-clockwise to reset the circuit. Restore plate voltage as detailed in stage 8.
12. Adjust the "Field Current" to 4 amps.
13. Set oscillator to 16 Hz. Check ASDS is in "Enable" mode. Reset ASDS. Turn ASDS gain down to zero.

OPERATOR CHECKLIST

C-5 Electrodynamic Shaker

14. Turn C-5 "Amplitude" control clockwise to the plastic stop. Switch ASDS ramp "UP". With ASDS ramp light "ON", slowly adjust ASDS gain clockwise until ASDS trips. Note the setting of the micrometer dial. The ASDS will trip at approximately ____ on the dial. System must trip and ramp vibration down. Switch ramp "DOWN". Reset ASDS. System is now ready for human testing.
15. Subject can be loaded - Seat belt adjusted. Check center on shaker. Adjust the centering spring if necessary.
16. Proceed with the test. - ASDS must remain in the "ENABLE MODE".
17. EMERGENCY SHUT DOWN
 - a) Push "Stop" button. - Shaker stops.
 - b) Ramp "Down" ASDS.
 - c) Turn "Amplitude" max counter-clockwise.
 - d) Turn "Plate" max counter-clockwise.
 - e) Turn "Field" max counter-clockwise.
 - f) Turn "Filament" max counter-clockwise.
 - g) Switch CB-39 "OFF".
 - h) Switch 220 VAC "OFF".
 - i) Disconnect cables.
18. Normal Stop between subjects. - Switch ASDS ramp "DOWN". Subject may unbuckle and step off platform.
19. Next subject may board and buckle seat belt. Check the center point - adjust if necessary. Proceed with test.
20. NORMAL CONCLUSION of TEST
 - a) Ramp "DOWN" ASDS.
 - b) Turn "Amplitude" max counter-clockwise.
 - c) Turn "Plate" max counter-clockwise.
 - d) Turn "Field" max counter-clockwise.
 - e) Turn "Filament" max counter-clockwise.
 - f) Press "STOP" button.
 - g) Switch CB-39 "OFF" (120 VAC)
 - h) Switch 220 VAC "OFF".
 - i) Disconnect cables.

C-5

Vibration Machine

Bldg. # 824

Mode Vertical

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
	1976								
	Feb. 11	1:15 PM	2:45 PM	0281.5	0283.0	—	—	Nelson # 20	CANCELLED - NO SHOW
	Feb. 12	8:15 AM	9:50 AM	0283.0	0284.6	8, 16	.102, .203	RENDER # 19	TRAINING
	Feb. 12	12:45 PM	2:40 PM	0284.6	0286.3	8, 16	.102, .203	DIMARCO # 6	TRAINING
	Feb. 13	11:30 AM	2:05 PM	0286.3	0287.6	8, 16	.102, .203	HAINZLER # 15	TRAINING
01	Feb 17	7:45 AM	11:05 AM	0287.6	0290.6	8	.102	HAINZLER # 15	1-8-150
02	Feb 17	12:00 PM	3:30 PM	0290.6	0293.9	8	.102	DIMARCO # 6	1-8-150
	Feb 18	7:45 AM	9:20 AM	0293.9	0295.5	8, 16	.102, .203	RUDO # 17	TRAINING
03	Feb 18	1:00 PM	4:25 PM	0295.5	0299.1	16	.203	BROOK # 19	1-16-150
04	Feb 19	12:05 PM	3:20 PM	0299.1	0302.7	16	.203	WILLIAMS # 06	2-16-150
	Feb 19	4:00 PM	5:20 PM	0302.7	0304.0	8, 16	.102, .203	FAAB # 12	TRAINING
	Feb 20	8:10 AM	9:40 AM	0304.0	0305.5	8, 16	.102, .203	ALCHOK # 11	TRAINING
05	Feb 20	1:20 PM	4:40 PM	0305.5	0305.7	0	.000	RENDER # 19	2-0-150
06	Feb 24	7:30 AM	11:30 AM	0305.7	0309.6	0	.000	HAINZLER # 15	2-0-150

Total Runs This Sheet

6

Run(s)

Total Cumulative Running Time

28.1

Total Hours This Sheet

28.1

Maintenance Problems

NONE

C - 5 Vibration Machine Bldg. #824

Mode Vertical

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
07	FEB 24	1:00 PM	4:30 PM	0307.6	0313.0	8	.102	FRANK #19	3-8-150
08	FEB 25	7:30 AM	11:05 AM	0313.0	0313.0	0	.000	FRANK #19	1-0-150
09	FEB 25	12:20 PM	2:50 PM	0313.0	0314.9	0	.000	D. MARCO #06	Run Aborted - FIRE ALARM 3-0-150
10	FEB 26	7:40 AM	11:10 PM	0314.9	0318.2	16	.203	HANDEK #15	3-16-150
11	FEB 27	8:00 AM	11:05 AM	0318.2	0321.3	8	.102	FRANK #19	2-8-150
12	FEB 27	12:40 PM	2:10 PM	0321.3	0322.6	8, 16	.102, .203	FAY #18	TRAINING
13	MAR 1	11:15 AM	4:35 PM	0322.6	0327.8	16	.153	BATONIC #9	1-16-240
14	MAR 2	7:00 AM	11:40 AM	0327.8	0332.6	8	.076	HANDEK #15	1-8-240
15	MAR 2	12:30 PM	3:35 PM	0332.6	0335.4	0	.000	D. MARCO #06	3-0-150
16	MAR 3	7:50 AM	4:45 PM	0335.4	0339.8	16	.203	FRANK #19	3-16-150
17	MAR 3	7:50 AM	4:45 PM	0339.8	0344.3	0	.000	FRANK #19	2-0-240
18	MAR 4	3:45 PM	6:50 PM	0344.3	0347.5	16	.203	BATONIC #12	1-16-150
19	MAR 5	11:00 AM	7:20 PM	0347.5	0352.9	8	.076	BREWER #19	3-8-240

Total Runs This Sheet 11Total Hours This Sheet 43.3

Total Cumulative Running Time

Maintenance Problems

NONE

Mode VERTICAL

C-5 Vibration Machine Bldg. #824

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
18	MAR 5 1976	11:00AM	7:20PM	0352.9	0355.7	8	.102	Emph #12	2-8-150
19	MAR 8	9:10AM	12:20PM	0355.7	0358.8	8	.102	FAY #18	1-8-150
20	MAR 9	7:00AM	11:45AM	0358.8	0363.5	0	.000	HANZIK #15	2-0-240
21	MAR 10	7:45AM	5:35PM	0363.5	0368.3	0	.000	Raddel #17	1-0-240
22	MAR 10	7:45AM	5:35PM	0368.3	0373.3	8	.076	D. Marco #06	1-8-240
	MAR 11	12:30PM	2:20PM	0373.3	0375.4	8, 16	.102, .203	15/17 #20	TRAINING
23	MAR 12	9:20AM	12:50PM	0375.4	0378.9	16	.203	FAY #18	2-16-150
24	MAR 12	1:30PM	6:10PM	0378.9	0383.6	16	.153	D. Marco #06	2-16-240
25	MAR 15	9:10AM	3:25PM	0383.6	0387.0	0	.000	FAY #18	3-0-150
26	MAR 15	9:10AM	3:25PM	0387.0	0389.9	0	.000	NE/SON #20	1-0-150
	MAR 16	12:00PM	12:10PM	0389.9	0390.1	16	.203	NE/SON #20	CANCELLED - CALLED IN
27	MAR 17	7:45AM	5:40PM	0390.1	0395.2	8	.076	Raddel #17	2-8-240
28	MAR 17	7:45AM	5:40PM	0395.2	0400.0	0	.000	D. Marco #06	3-0-240

Total Runs This Sheet 11 Total Hours This Sheet 47.1
 Total Cumulative Running Time 118.5 Maintenance Problems NONE

C-5 Vibration Machine Bldg. #824

Mode Vertical

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQ. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
29	MAR 18	12:00 PM	3:45 PM	0400.0	0403.6	16	.203	Ph. Koon #20	2-16-150
	MAR 19	11:30 AM	11:50 AM	0403.6	0404.0	8	.076	FAY #18	1-8-240 CANCELLED - CALLED IN
30	MAR 22	7:45 AM	4:20 PM	0404.0	0409.1	16	.153	Rudd #17	3-16-240
31	MAR 22	7:45 AM	4:20 PM	0409.1	0412.3	8	.102	Nelson #20	3-8-150
32	MAR 23	11:05 AM	4:30 PM	0412.3	0417.6	8	.076	FAY #18	1-8-240
33	MAR 24	7:45 AM	5:30 PM	0417.6	0427.1	16	.091	ERDMAN #19	1-16-480
34	MAR 25	7:00 AM	12:05 PM	0427.1	0432.3	16	.153	HAINZEL #15	3-16-240
35	MAR 26	10:45 AM	3:45 PM	0432.3	0437.2	16	.153	FAY #18	2-16-240
	MAR 30	11:35 AM	11:20 AM	0437.2	0437.8	0	1.000	FAY #18	3-0-240 CANCELLED (MEDICINE)
36	MAR 31	7:45 AM	5:35 PM	0437.8	0447.5	0	.000	Rudd #17	1-0-480
37	Apr 1	6:55 AM	4:27 PM	0447.5	0457.1	8	.045	D. Pharo #06	1-8-480
38	Apr 6	10:40 AM	3:30 PM	0457.1	0462.0	0	.000	FAY #18	3-0-240
39	Apr 17	7:30 AM	5:45 PM	0462.0	0472.1	8	.045	Rudd #17	2-8-480

Total Runs This Sheet 11

Run(s)

Total Hours This Sheet

72.1

Total Cumulative Running Time

190.6

Maintenance Problems

NONE

C-5

Vibration Machine

Bldg.

#824

Mode DEFICIAL

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
40	Apr 12 1976	7:35 AM	5:20 PM	0472.1	0481.7	0	.000	Freud #19	2-0-480
41	Apr 13	6:30 AM	11:35 PM	0481.7	0491.4	16	.091	D. Marco #06	2-16-480
42	Apr 14	7:30 AM	5:32 PM	0491.4	0501.3	16	.091	Rugel #11	3-16-480
43	Apr 19	7:40 AM	5:30 PM	0501.3	0511.0	8	.045	Brenner #19	3-8-480
	Apr 20	3:05 PM	6:00 PM	0511.0	0513.9	0	.000	Aclos #11	CANCELLED
	Apr 21	6:50 AM	2:00 PM	0513.9	0521.0	0	.000	D. Marco #06	1-0-150 No show
44	Apr 22	3:20 PM	8:30 PM	0521.0	0529.5	0	.000	Enab #12	Block 12 - Run Aborted
45	Apr 23	10:30 AM	3:40 PM	0529.5	0530.8	0	.000	Nelson #20	3-0-480 RECORDED OUT
46	Apr 26	7:45 AM	5:20 PM	0530.8	0540.4	8	.045	Fay #18	3-0-150
47	Apr 27	6:50 AM	4:30 PM	0540.4	0549.9	0	.000	D. Marco #06	1-0-210
48	Apr 28	10:45 AM	4:20 PM	0549.9	0555.4	16	.153	Nelson #20	1-8-480
49	May 4	7:45 AM	5:25 PM	0555.4	0565.0	16	.091	Fay #18	3-0-480
50	May 5	11:30 AM	4:30 PM	0565.0	0569.7	8	.076	Nelson #20	2-16-240
									2-16-480
									3-8-240

Total Runs This Sheet 11

Run(s)

Total Hours This Sheet 97.6

Total Cumulative Running Time 288.2

Maintenance Problems

None

C-5

Vibration Machine

Bldg. 824Mode VERTICAL

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
51	14 MAY 76	7:45 AM	5:35 PM	0569.7	0578.8	0	0	Nelson # 20	1-0-480
52	17 MAY 76	7:40 AM	5:40 PM	0578.8	0588.9	16	.091	Nelson # 20	2-16-480
53	21 MAY 76	7:45 AM	8:50 AM	0588.9	0589.7	8	.045	Nelson # 20	3-8-480 SUBJECT ILL RUN CANCELLED
54	3 JUNE	7:35 AM	5:15 PM	0589.7	0599.1	0	.000	FAY #18	3-0-480
55	4 JUNE	7:45 AM	5:30 PM	0599.1	0608.7	8	.045	HAINZEL #15	1-8-480
56	10 JUNE	7:40 AM	5:20 PM	0608.7	0609.1	0	.000	HAINZEL #15	2-0-480
57	11 JUNE	7:45 AM	5:30 PM	0609.1	0618.9	8	.045	Nelson # 20	3-8-480
58	15 JUNE	3:45 PM	9:15 PM	0618.9	0624.2	16	.153	BAAB #12	1-16-240
59	16 JUNE	0:00 PM	0:00 PM	0624.2	0624.2	0	.000	M. Fay #21	1st TRAINING
60	17 JUNE	3:30 PM	9:09 PM	0624.2	0629.5	8	.096	BAAB #12	2-8-240
61	18 JUNE	7:45 AM	5:05 PM	0629.5	0636.9	16	.091	HAINZEL #15	13-16-480
62	21 JUNE	12:45 PM	2:50 PM	0638.9	0641.0	8, 16	.102, .203	M. Fay #21	2nd TRAINING
63	22 JUNE	3:00 PM	9:00 PM	0641.0	0647.0	0	.000	BAAB #12	3-0-240

Total Runs This Sheet 10

Run(s)

Total Hours This Sheet 17.3Total Cumulative Running Time 365.5Maintenance Problems NONE

C-5 Vibration Machine Bldg. 824

Mode Vertical

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQ. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
61	23 June 1976	8:03 AM	11:20 AM	0647.0	0650.2	0	.000	M.Fay #21	1-0-150
62	25 June	8:15 AM	11:55 AM	0650.2	0653.8	8	.102	M.Fay #21	2-8-150
63	28 June	7:47 AM	5:10 PM	0653.8	0663.3	16	.091	BAAB #12	1-16-480
	29 June	7:35 AM	7:50 AM	0663.3	0663.6	8	.045	BAAB #12	2-8-480 (HACK & HELD)
64	30 June	8:00 AM	11:35 AM	0663.6	0668.1	16	.203	M.Fay #21	3-16-150
65	9 July	10:30 AM	3:45 PM	0668.1	0672.4	0	.000	M.Fay #21	1-0-240
	12 July	1:30 PM	4:35 PM	0672.4	0675.5	8, 16	.260 - .613	Rudd #17	TRAINING (short term)
	12 July	1:30 PM	4:35 PM	0675.5	0675.5	8, 16	.260 - .613	D.Fay #18	TRAINING (short term)
66	13 July	10:25 AM	4:45 PM	0675.5	0680.7	8	.076	M.Fay #21	2-8-240
67	13 July	10:25 AM	4:45 PM	0680.7	0681.9	8	.306	D.Fay #18	1-8-016
	14 July	8:20 AM	10:10 AM	0681.9	0683.6	8, 16	.260 - .613	HANDOVER #15	TRAINING (short term)
68	14 July	2:20 PM	3:55 PM	0683.6	0685.2	0	.000	Rudd #17	1-0-016
69	15 July	3:50 PM	4:45 PM	0685.2	0686.0	16	.613	D.Fay #18	2-16-016

Total Runs This Sheet 9 Total Hours This Sheet 39.0

Total Cumulative Running Time 404.5 Maintenance Problems NONE

C-5 Vibration Machine Bldg. 824Mode VERTICAL

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
70	16 July 1976	2:20pm	4:20pm	0686.0	0688.0	8	.306	Rudd #17	2-8-016
71	17 July	8:00am	5:35pm	0688.0	0697.4	8	.045	Rudd #12	2-8-480
72	19 July	1:30pm	4:30pm	0697.4	0699.6	0	.000	Globig #22	1st TRAINING
73	19 July	1:30pm	4:30pm	0699.6	0700.2	0	.000	D. Fay #18	3-0-016
74	20 July	11:40am	3:15pm	0700.2	0702.0	8, 16	.260-.613	Globig #22	2nd TRAINING
75	20 July	11:40am	3:15pm	0702.0	0703.6	16	.613	Rudd #17	3-16-016
76	28 July	2:40pm	4:10pm	0703.6	0705.1	0	.000	Rudd #17	1-0-025
77	29 July	8:00am	9:20am	0705.1	0706.4	8	.260	Fay #18	1-8-025
78	31 July	7:45am	5:30pm	0706.4	0716.0	0	.000	BHAB #12	3-0-480
79	2 Aug	10:10am	4:30pm	0716.0	0720.8	16	.153	Fay #21	3-16-240
80	2 Aug	10:10am	4:30pm	0720.8	0722.2	8	.260	Rudd #17	2-8-025
81	3 Aug	8:05am	11:00am	0722.2	0723.4	16	.512	D. Fay #18	2-16-025
82	3 Aug	8:05am	11:00am	0723.4	0724.7	8, 16	.260-.613	FOREMAN #19	TRAINING (No Show)

Total Runs This Sheet 10

Run(s)

Total Hours This Sheet 38.7Total Cumulative Running Time 443.2Maintenance Problems NONE

C-5 Vibration Machine Bldg. 824Mode Vertical

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
80	1976 4 Aug	8:00 AM	10:35 AM	0724.7	0725.8	0	.000	Globig #22	1-0-016
81	4 Aug	8:00 AM	10:35 AM	0725.8	0727.3	8	.306	HANZLER #15	1-8-016
82	4 Aug	2:20 PM	4:20 PM	0727.3	0729.3	16	.512	Kudl #17	3-16-025
83	5 Aug	8:05 AM	9:50 PM	0729.3	0731.0	0	.000	P. Fay #18	3-0-025
84	6 Aug	7:30 AM	5:35 PM	0732.5	0742.6	0	.000	M. Fay #21	1-0-480
85	9 Aug	8:00 AM	11:15 AM	0742.6	0743.7	16	.613	Globig #22	2-16-016
86	9 Aug	8:00 AM	11:15 AM	0743.7	0745.9	0	.000	HANZLER #15	2-0-016
87	9 Aug	3:55 PM	5:00 PM	0745.9	0747.0	16	.613	BANK #12	1-16-016
88	10 Aug	7:35 AM	5:25 PM	0747.0	0756.8	8	.045	M. Fay #21	2-8-480
89	11 Aug	8:15 AM	10:40 AM	0756.8	0758.5	8	.306	Globig #22	3-8-016
90	11 Aug	8:15 AM	10:40 AM	0758.5	0759.2	16	.613	HANZLER #15	3-16-016
91	11 Aug	4:15 PM	5:00 PM	0759.2	0759.9	8	.306	Bank #12	2-8-016
92	13 Aug	8:10 AM	10:30 PM	0759.9	0762.3	0	.000	Globig #22	1-0-025

Total Runs This Sheet 13Run(s) 480.8Total Hours This Sheet 37.6Maintenance Problems NONE

C-5 Vibration Machine Bldg. 821Mode VERTICAL

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
93	13 Aug 1976	8:10 AM	10:30 AM	0762.3	0763.5	8	.260	HAMMER #15	1-8-025
94	13 Aug	3:30 PM	5:00 PM	0763.5	0764.7	0	.000	PAUL #12	3-0-016
95	16 Aug	8:00 AM	10:05 AM	0764.7	0765.9	16	.512	GLOBE #22	2-16-025
96	16 Aug	8:00 AM	10:05 AM	0765.9	0766.8	0	.000	HAMMER #15	2-0-025
	17 Aug	8:30 AM	10:10 AM	0766.8	0768.5	0	.000	RODERS #24	1st TRAINING
	17 Aug	12:40 PM	2:45 PM	0768.5	0770.5	0	.000	NOSEK #25	1st TRAINING
97	18 Aug	8:15 AM	10:25 PM	0770.5	0771.6	8	.260	GLOBE #22	3-8-025
	18 Aug	8:15 AM	10:25 PM	0771.6	0772.6	16	.512	HAMMER #15	3-16-025 (No Show)
98	18 Aug	4:25 PM	5:20 PM	0772.6	0773.3	16	.512	PAUL #12	1-16-025
	19 Aug	8:00 AM	2:30 PM	0773.3	0775.3	8, 16	.26-.613	RODERS #24	CANCELLED-MEDICAL 2ND TRAINING
	19 Aug	9:00 AM	2:30 PM	0775.3	0778.0	0	.000	CUKOVET #26	1st TRAINING
	19 Aug	8:00 AM	2:30 PM	0778.0	0779.7	8, 16	.260-.613	NOSEK #25	2ND TRAINING
99	20 Aug	9:35 AM	10:45 AM	0779.7	0780.9	16	.512	HAMMER #15	3-16-025

Total Runs This Sheet 7

Run(s)

Total Hours This Sheet

18.6

Total Cumulative Running Time

499.4

Maintenance Problems

C-5 Vibration Machine Bldg. 824Mode VERTICAL

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
100	20 Aug 1976	4:25 PM	5:15 PM	0780.9	0781.7	8	.260	BAB #12	2-8-025
	23 Aug	9:15 AM	5:15 PM	0781.7	0783.7	8, 16	.260-.613	Cukovecki #26	2nd TRAINING
	23 Aug	9:50 AM	5:15 PM	0783.7	0787.1	0	.000	KLOSTERMAN #23	1ST TRAINING
101	23 Aug	9:50 AM	5:15 PM	0787.1	0788.9	0	.000	BAB #12	3-0-025
102	24 Aug	9:25 AM	4:40 PM	0788.9	0791.0	0	.000	Cukovecki #26	1-0-016
	24 Aug	9:25 AM	4:40 PM	0791.0	0793.8	8, 16	.260-.613	KLOSTERMAN #23	2ND TRAINING
103	24 Aug	9:25 AM	4:40 PM	0793.8	0795.1	16	.613	NOSKER #25	1-16-016
104	25 Aug	7:45 AM	5:25 PM	0795.1	0804.8	16	.091	W. Day #21	3-16-480
	26 Aug	10:40 AM	11:55 AM	0804.8	0806.0	8	.306	Cukovecki #26	2-8-016 (NO SHOW)
105	26 Aug	1:45 PM	2:40 PM	0806.0	0806.9	0	.000	NOSKER #25	2-0-016
	27 Aug	9:35 AM	3:40 PM	0806.9	0809.0	0	.000	W. Day #21	1st TRAINING
106	27 Aug	9:35 AM	3:40 PM	0809.0	0810.9	0	.000	KLOSTERMAN #23	1-0-016
107	27 Aug	9:35 AM	3:40 PM	0810.9	0811.9	8	.306	NOSKER #25	3-8-016

Total Runs This Sheet 8Total Hours This Sheet 31.0Total Cumulative Running Time 530.4

Maintenance Problems

NONE

Mode VERTICALC-5 Vibration Machine Bldg. 821

VIBRATION MACHINE RUNNING LOG

UDRI RUN	Date	T I M E				FREQU. (Hz)	ACCEL. (peak "g")	SUBJECT	RUN NUMBER
		Power On	Power Off	Meter On	Meter Off				
108	30 Aug 1976	7:45 AM	2:50 PM	0811.9	0814.8	8	.306	Cukorecki #26	2-8-016
109	30 Aug	9:45 AM	2:50 PM	0814.8	0815.4	8	.306	Klostermann #23	2-8-016
110	30 Aug	9:45 AM	2:50 PM	0815.4	0816.7	16	.512	Nosker #25	1-16-025
111	1 Sept	8:30 AM	2:55 PM	0816.7	0823.5	8, 16	.260-.613	McGath #27	2ND TRAINING
112	1 Sept	8:30 AM	2:55 PM	0823.5	0825.4	16	.613	Klostermann #23	3-16-016
113	2 Sept	9:45 AM	11:45 AM	0826.6	0828.4	16	.613	Nosker #25	2-0-025
114	2 Sept	1:30 PM	2:50 PM	0828.4	0829.7	8	.260	Cukorecki #26	3-16-016
115	8 Sept	8:30 AM	1:40 PM	0829.7	0831.8	8	.306	Nosker #25	3-8-025
116	8 Sept	8:30 AM	1:40 PM	0831.8	0834.8	0	.000	McGath #27	1-8-016
117	9 Sept	9:30 AM	1:45 PM	0834.8	0836.8	0	.000	Klostermann #23	1-0-025
118	9 Sept	9:30 AM	1:45 PM	0836.8	0838.8	8	.260	Cukorecki #26	1-0-025
119	13 Sept	9:45 AM	1:50 PM	0838.8	0839.7	16	.613	Klostermann #23	2-8-025
								McGath #27	2-16-016

Total Runs This Sheet 12Total Hours This Sheet 27.8Total Cumulative Running Time 558.2Maintenance Problems NONE

[illegible]

Total Runs This Sheet	<u>7</u>	Run(s)	<u>567.4</u>	Total Hours This Sheet	<u>9.2</u>
Total Cumulative Running Time				Maintenance Problems	<u>None</u>