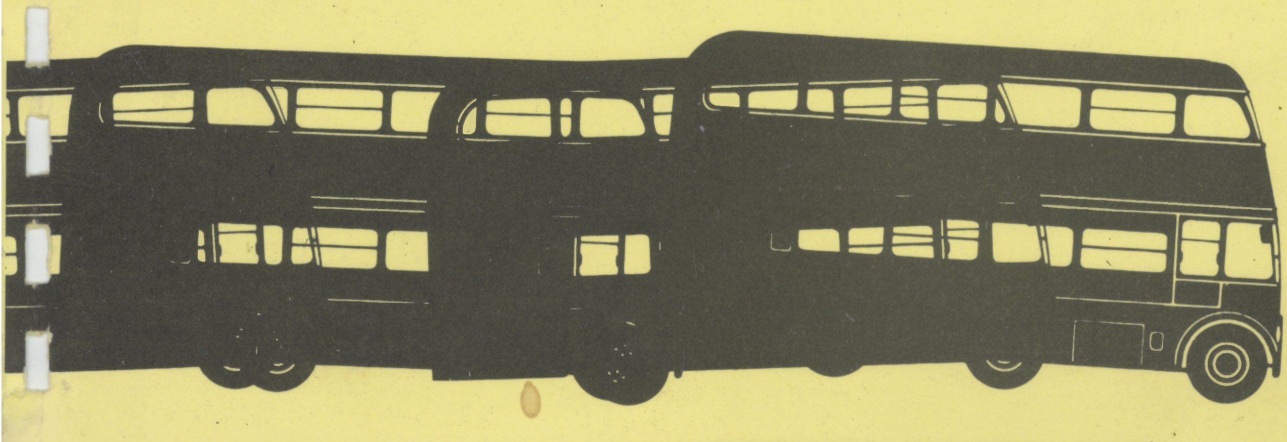
UNIVERSITY of SALFORD



# HUMAN REACTION TO VIBRATION



SEPTEMBER 1973

# HUMAN RESPONSE TO VIBRATION CONFERENCE

## Timetable

### Monday 17 September

| | |
|---|---|
| 2.00 pm - 10.00 pm | Registration |
| 6.30 pm - 10.00 pm | Dinner (Cold Buffet) |

### Tuesday 18 September

| | |
|---|---|
| 8.00 am - 9.00 am | Breakfast |
| 9.15 am - 9.30 am | Welcome Speech, Professor P Lord |
| 9.30 am - 11.10 am | Session 1 |
| 11.10 am - 11.30 am | C O F F E E |
| 11.30 am - 12.50 pm | Session 2 |
| 1.00 pm - 2.15 pm | L U N C H |
| 2.15 pm - 3.35 pm | Session 3 |
| 3.35 pm - 3.55 pm | T E A |
| 3.55 pm - 4.55 pm | Session 4 |
| 4.55 pm - 5.30 pm | General Discussion |
| 7.00 pm | Sherry Reception |
| 7.30 pm | Conference Dinner |

### Wednesday 19 September

| | |
|---|---|
| 8.00 am - 9.00 am | Breakfast |
| 9.30 am - 10.50 am | Session 5 |
| 10.50 am - 11.20 am | C O F F E E |
| 11.20 am - 12.20 pm | Session 6 |
| 12.20 pm - 12.45 pm | General Discussion |
| 12.45 pm - 1.00 pm | Venue of next conference and AOB |
| 1.00 pm | L U N C H |

P R O G R A M M E

Tuesday 18 September

| | |
|---|---|
| 9.15 | P Lord, Professor of Acoustics, University of Salford |

**Session I** Chairman: Dr J C Guignard

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|---|---|
| 9.30 | LABORATORY STUDIES OF THE EFFECT OF VIBRATION ON HUMAN VISION<br>Dr M J Griffin |
| 9.45 | TRANSMISSION OF ANGULAR ACCELERATION TO THE HEAD<br>Wing Commander B H Rance and G R Barnes |
| 10.00 | EFFECTS OF POSTURAL CHANGES ON THE HEAD RESPONSE OF STANDING SUBJECTS SUBJECTED TO LOW FREQUENCY 'CONSTANT VELOCITY' SPECTRAL INPUTS<br>B K H Rao and B Jones |
| 10.15 | MOVEMENT OF THE HEAD DURING VIBRATION<br>J Sandover and R Soames |
| 10.30 | FURTHER STUDIES OF THE TUNNEL VISION PHENOMENA DURING VIBRATION<br>P M J Bulger and Dr A J Simpson (not presented) |
| 10.45 | DISCUSSION |
| 11.10 | C O F F E E |

**Session 2** Chairman: Mr G R Allen

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|---|---|
| 11.30 | A SCALE OF HUMAN RESPONSE TO WHOLE BODY VERTICAL SINUSOIDAL VIBRATION<br>Dr A J Jones |
| 11.45 | CROSS MODALITY DETERMINATION OF THE GROWTH FUNCTION FOR WHOLE BODY VERTICAL VIBRATION<br>Dr T I Hempstock and Dr D J Saunders |
| 12.00 | THE USE OF RATING TIMES TO OBTAIN EQUAL SENSATION ZONES<br>D J Oborne (not presented) |
| 12.15 | THE USE OF LINEAR TECHNIQUES TO ASSESS HUMAN RESPONSES TO MECHANICAL STIMULI<br>J Sandover |
| 12.30 | DISCUSSION |
| 12.50 | END OF SESSION |
| 1.00 | L U N C H |

**Session 3** Chairman: Dr D J Saunders

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|---|---|
| 2.15 | RESPONSE CHARACTERISTICS OF SEATS<br>G F Rowlands |
| 2.30 | RIDE VIBRATION ON AGRICULTURAL TRACTORS<br>R M Stayner |
| 2.45 | HUMAN RESPONSE TO COMPLEX VERTICAL WHOLE BODY VIBRATIONS<br>L C Fothergill |
| 3.00 | LONG TERM EFFECTS OF VIBRATION, A PRELIMINARY EXPERIMENT<br>R Gray |
| 3.15 | DISCUSSION |
| 3.35 | T E A |

Session 4 Chairman: Dr T I Hempstock

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|---|---|
| 3.55 | EPIDEMIOLOGICAL AND CLINICAL ASPECTS OF RAYNAUD'S PHENOMENON OF OCCUPATIONAL ORIGIN<br>Dr W Taylor |
| 4.10 | THE PARAMETERS OF HAND/ARM VIBRATION AND THEIR MEASUREMENT<br>D E O'Connor and Dr T I Hempstock |
| 4.25 | VIBRATION MEASUREMENTS IN CHAIN SAWS AND ACCEPTABLE VIBRATION STANDARDS<br>G D Keighley |
| 4.40 | DISCUSSION |
| 5.30 | END OF SESSION |

Wednesday 19 September

Session 5 Chairman: Dr M J Griffin

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|---|---|
| 9.30 | Professor A Berthoz |
| 9.45 | INDUSTRIAL ELECTRODYNAMIC VIBRATOR FOR HUMAN EXPERIMENTATION- A FEASIBILITY STUDY<br>William H Muzzy III, Channing L Ewing, Perry W Seal |
| 10.00 | PROBLEMS IN THE INTERNATIONAL STANDARDISATION OF TERMINOLOGY RELATING TO HUMAN VIBRATION EXPOSURE<br>Dr J C Guignard |
| 10.15 | LOW FREQUENCY VIBRATION<br>G R Allen |
| 10.30 | DISCUSSION |
| 10.50 | C O F F E E |

Session 6 Chairman: Dr R J Whitney

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|---|---|
| 11.20 | A PRELIMINARY STUDY INTO THE EFFECTS OF ABNORMAL ENVIRONMENTS ON HUMAN STEROID EXCRETION<br>S H Cole |
| 11.35 | SOME PHYSIOLOGICAL MEASUREMENTS OF THE HUMAN RESPONSE TO VERTICAL VIBRATION<br>Miss M C Cursiter and R H Harding |
| 11.50 | MATHEMATICAL AND PSYCHOLOGICAL MODELLING OF THE HUMAN BODY'S RESPONSE TO VIBRATION<br>Mrs H M Hearnshaw |
| 12.05 | DISCUSSION |
| 12.45 | VENUE OF NEXT CONFERENCE and ANY OTHER BUSINESS |
| 1.00 | L U N C H |

# Whole-body Vibration Levels Affecting Visual Acuity.

By: M.J. Griffin, Ph.D.

August, 1973

Institute of Sound and Vibration Research, University of Southampton.

## ABSTRACT

A visual task has been devised to investigate the effects of whole-body vibration on eye-movements and vision. This task is the detection of retinal blur and is considered to be as sensitive as any suitable alternative measure of visual acuity.

Minimum levels of vibration reuired to produce blur have been determined under several conditions of object and subject vibration. The present experiment employed vertical sinusoidal vibration (7 to 75 Hz) and demonstrates a large intersubject variability in the levels of whole-body vibration required to produce blur. This variability has been compared with the potentially large intrasubject variability due to changes in body posture.

The experimental results have led to the tentative recommendations of vibration levels below which vibration is not normally expected to reduce visual acuity.

## 1. INTRODUCTION

The determination of the effect of whole-body vibration on visual acuity has been a stated objective of approximately fifty previous whole-body vibration experiments. The findings from these earlier experiments are reviewed elsewhere (Griffin 1973) and the present paper will solely detail one experiment designed to provide information in an important area not previously investigated.

The experiment to be described was designed to determine the characteristics of seat and head vibration at the lowest vibration levels that could cause decrements in visual acuity. The experiment employed vertical sinusoidal vibration in the frequency range 7 to 75 Hz.

## 2. RELEVANT VARIABLES

Vibration frequency, level and axis are obvious factors likely to affect human response to vibration. Other factors, such as body orientation, body posture, the nature of the seat and the type of restraint can also affect the distibution of vibration within the body. Further variables relevant to a visual acuity experiment are the nature of the visual task, how performance at the task is scored, brightness, contrast, viewing distance etc.

The experiment to be described employed conditions chosen to be simple, clearly defined and repeatable.

Subjects were exposed to vertical, sinusoidal vibration on a hard flat wooden seat. (Distortion levels and background vibration were low and have been shown to be insignificant in the context of the experiment). The feet of subjects rested horizontally on a stationary foot rest adjusted vertically so that the subjects' thighs were horizontal. Subjects were not restrained by a belt or harness. Noise levels were 50 to 55 dBA and temperature 18 to 23$^o$ C.

The visual task consisted of detecting the movement on the retina of the images of four 'points' of light. The four sources of light were 20 feet infront of the subjects and located at the corners of a 20 cm square. The light sources consisted of four 0.012 inch diameter holes in a stainless steel sheet. The holes were illuminated evenly from behind at a level of approximately 400 lux. The illumination in the laboratory was adjusted so that after about 10 minutes dark adaption subjects would be able to see sufficient detail to leave the room in an emergency.

## 3. VISUAL BLUR AND VISUAL ACUITY

Visual acuity is a quantity that is highly dependent on the method of measurement. In consequence, measures of acuity must be accompanied by a description of the measurement method. Further, acuity tasks are often without clear characteristics which enable the use of results obtained from one task in predicting effects with another task. Visual blur was chosen for the present experiment because it is any easily repeatable task, it tests a definable property of the visual system and it is equally sensitive to motion in the vertical and lateral directions.

Blur will affect the quality of an image but may or may not render detail indiscernible. The vibration level that produces a particular type of blur will affect other measures of acuity in a manner that depends on the acuity task, illumination, contrast, vibration frequency and axis etc. Thus, while the blur of a point source of light is largely a charactertistic of the motion of the image, most other measures of acuity will depend on both image motion and the form of the test object.

It is believed that the detection of blur has a sensitivity which is equivalent or greater than that of other visual acuity tasks. The knowledge of levels that produce blur may be applied directly to the assessment of some practical visual acuity tasks and, indirectly, to many other visual tasks.

## 4. EXPERIMENTAL DESIGN

Twelve male research workers from the University of Southampton acted as subjects. Their ages ranged from 21 to 35 years, heights 68 to 74½ inches, weights 140 to 194lbs, Snellen visual acuity 6/5 or better (in tested eye). Six subjects were tested with the right eye and six with the left. The eye not being tested was covered by an eye patch.

In brief, the balanced experiment required that for each vibration frequency the subject should adjust his posture to produce the sensation of maximum vibration at the head. He then adjusted the vibration level at the seat until it was at the minimum level that produced a definite blurring or movement of the points of light due to the vibration. This is called the 'blur level'. (With prectice, subjects generally found this a reasonable request.) This procedure was relicated six times at the fifteen frequencies of 7,10,15,20,25,30,35,40,45,50,55,60,65,70 75 Hz. (The subjects were tested at all these frequencies between the replica- of each frequency.)

Throughout the experiment the vertical vibration of both the seat and the head of each subject were monitored. (The latter was achieved with a bar held by the subjects' teeth.) In addition, lateral head motion was monitored for subjects 1 to 4, fore and aft head motion for subjects 5 to 8 and pitch head motion for subjects 9 to 12.

## 5. EXPERIMENTAL RESULTS

The mean vertical vibration levels at the seat and the head of each subject at the blur level are shown in figure 1. (The data for subject 6 is incomplete since above 40 Hz the level of seat vibration required by this subject was greater than the predetermined maximum level permitted by the experimenter. For the same reason the data for subject 11 is based on only three or four judgements at some frequencies. The results obtained from subjects 6 and 11 have been eliminated from the following statistical analysis.)

Figures 2a and 2b show the mean and standard deviation of vertical vibration at the seat and head of the ten subjects. The standard deviations indicate large intersubject variances at all frequencies. Multifactor analyses of variance have shown that the blur level depends significantly on vibration frequency at the seat ($P<0.001$) and at the head ($P<0.05$). There is no main effect due to the repetition at each frequency.

It may be observed from figure 1 that relevant resonances are highly characteristic of an individual. Table 1 show that for vertical head acceleration the frequency of maximum sensitivity varied from 25 to 70 Hz between individuals and no more than two of the twelve subjects agreed on which frequency was the 'worst'.

(Note: These minima are defined as frequencies at which the blur level is less than at the two adjacent frequencies. There are therefore no entries for 7 or 75 Hz although all but two of the subjects gave a lower setting at 7 Hz than 10 hz.)

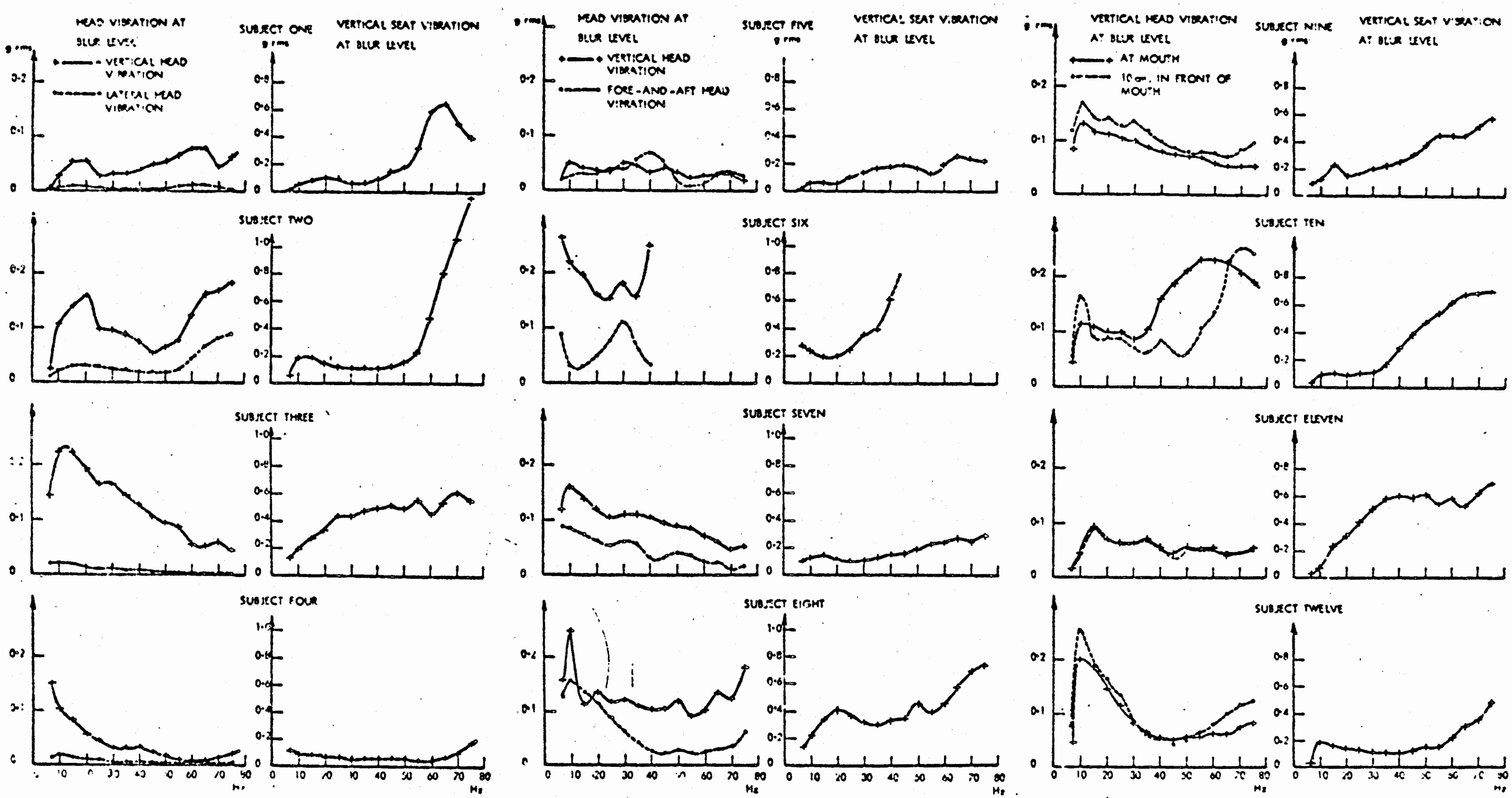


Figure 1. Mean levels of seat and head vibration at blur level

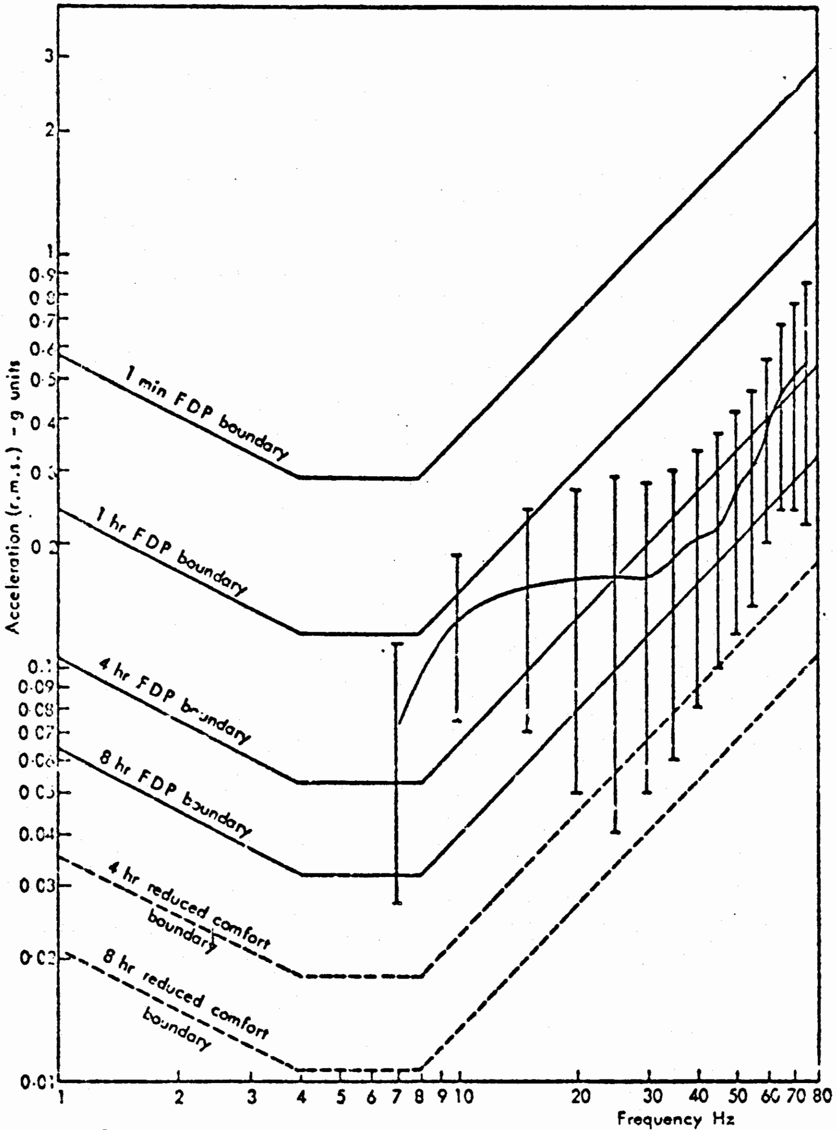


FIG 2a MEAN AND STANDARD DEVIATION OF VERTICAL SEAT VIBRATION OF 10 SUBJECTS AT BLUR LEVEL

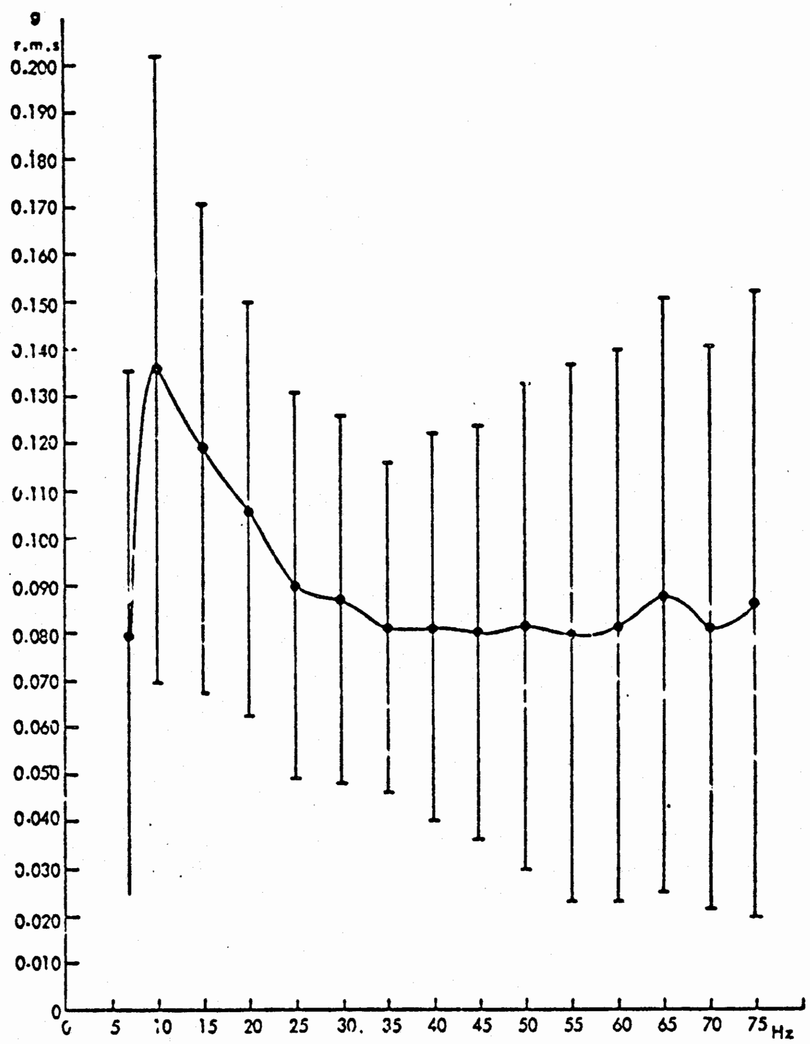


FIG 2b MEAN AND STANDARD DEVIATION OF VERTICAL HEAD VIBRATION OF 10 SUBJECTS AT BLUR LEVEL

## TABLE 1.

**The location of frequencies of maximum sensitivity to vertical head acceleration.**

| FREQUENCY, Hz | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF SUBJECTS WITH ABSOLUTE MINIMA | - | - | 2 | 1 | - | - | 2 | - | 2 | 1 | 2 | 2 |
| NUMBER OF SUBJECTS WITH LOCAL MINIMA | 1 | 1 | 6 | 2 | 2 | 2 | 3 | - | 3 | 1 | 3 | 4 |

The data obtained on non vertical head motion will not be presented in this paper.

## 6. DISCUSSION

A separate experiment conducted with the twelve subjects used in the present experiment determined the effect of body posture on the transmissibility of vertical vibration to the head. This data is shown in figure 3 together with the transmissibility determined in the present acuity experiment.

The mean effects due to changes in posture are greatest at 45 Hz where head vibration is six times greater in the severe posture than in the less severe posture. This six to one range due to intrasubject variability compares to an approximate ten to one range due to intersubject variability in the level of seat vibration required to produce blur.

The mean values of seat vibration that produced visual blurring (figure 2a) represents the vibration level at which about 50% of the subjects observed perceptible blur when sitting in the severe posture. The adoption of less severe postures would result in fewer subjects perceiving a blur and, in the least severe posture, this mean level would have rarely produced blurring.

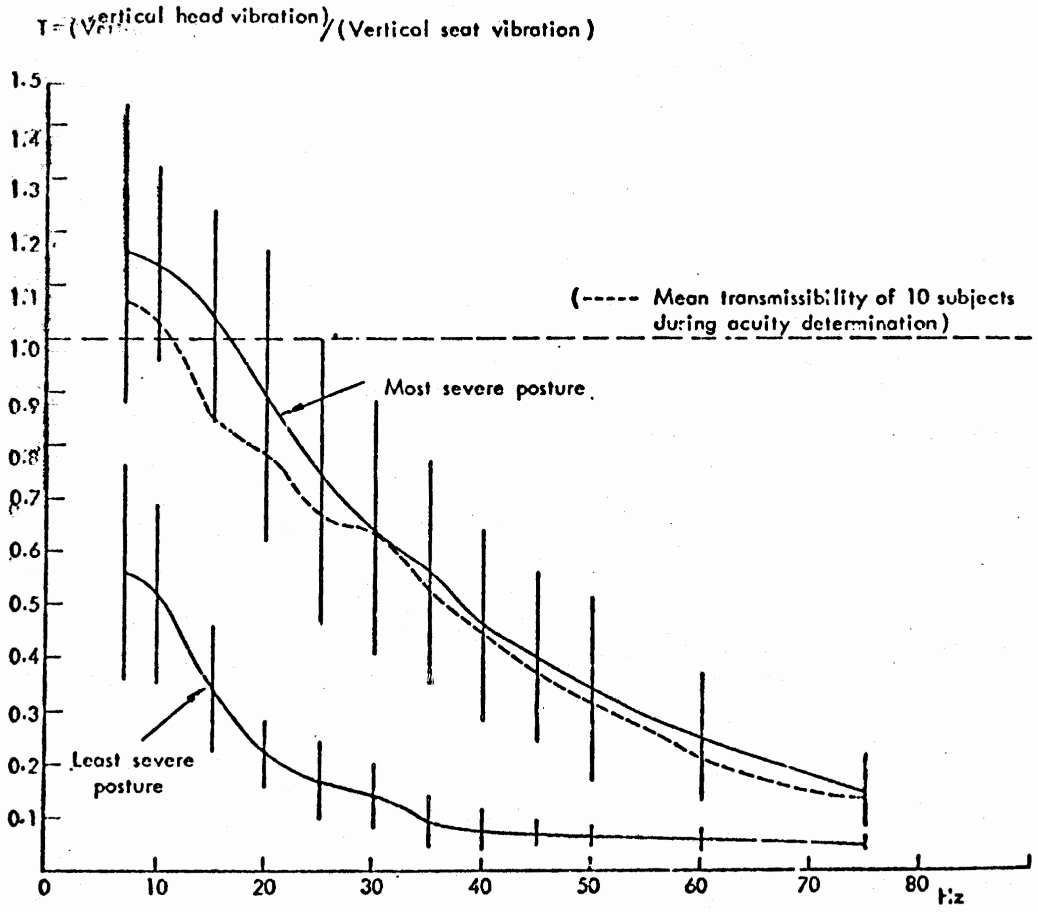


Figure 3. The mean and standard deviation of transmissibility of twelve seated subjects at six levels (0.05 to 0.5g rms) of vertical vibration for two extreme postures. (Dotted line indicates the transmissibility measured during the present experiment.)

The experimental data suggested that "vertical seat vibration levels which exceed those mean levels shown in figure 2a (and replotted in figure 4) may, depending on the subject, the seat and the visual task, present problems of visual acuity".

Also shown in figure 4 is a similar boundary obtained, from a separate experiment, for the vibration of an object in front of a stationary observer. These recommended levels of object vibration are partially

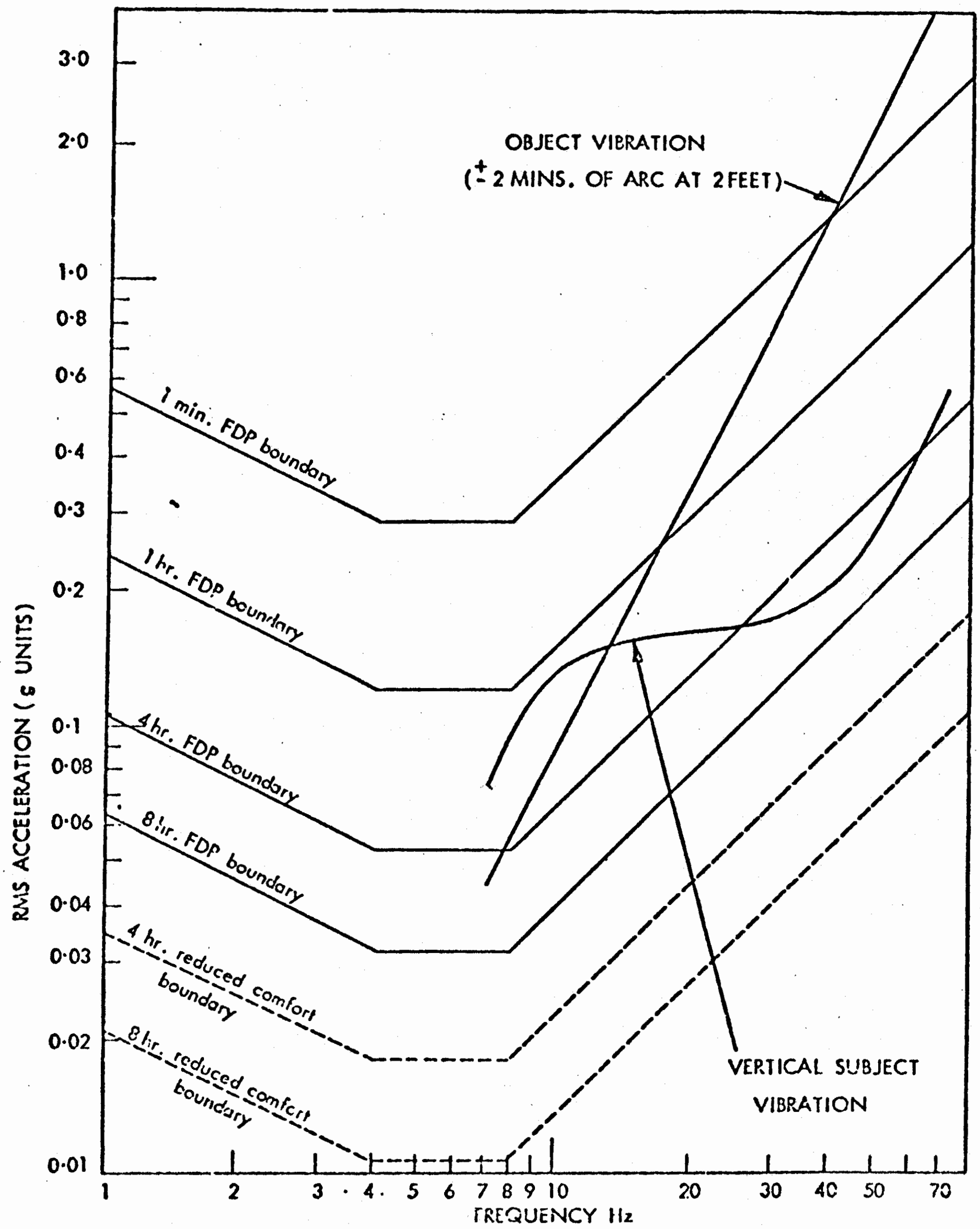


Figure 4. Vibration levels below which vibration is not normally expected to reduce visual acuity.

coroborated by earlier experiments with the vibration of Landolt C test objects, (O'Hanlon and Griffin 1971)

## 7. CONCLUSIONS

Experimental results have led to the tentative recommendation of vibration levels below which vibration is not normally expected to reduce visual acuity.

The experiment revealed a considerable intersubject variability and a very much larger subject sample is required for the determination of a useful distribution of blur levels. It would be technically possible to determine the vibration levels that would produce blur in chosen percentiles of the population. However, such precision will be of practical value only when the effects of other variables are equally well determined.

## 8. REFERENCES


1. Griffin, M.J. (1973), "Vibration and Visual Acuity" To be published.

2. O'Hanlon, J.G. and Griffin, M.J. (1971), Some Effects of the Vibration of Reading material upon Visual Performance. I.S.V.R. Technical Report No. 49, University of Southampton.

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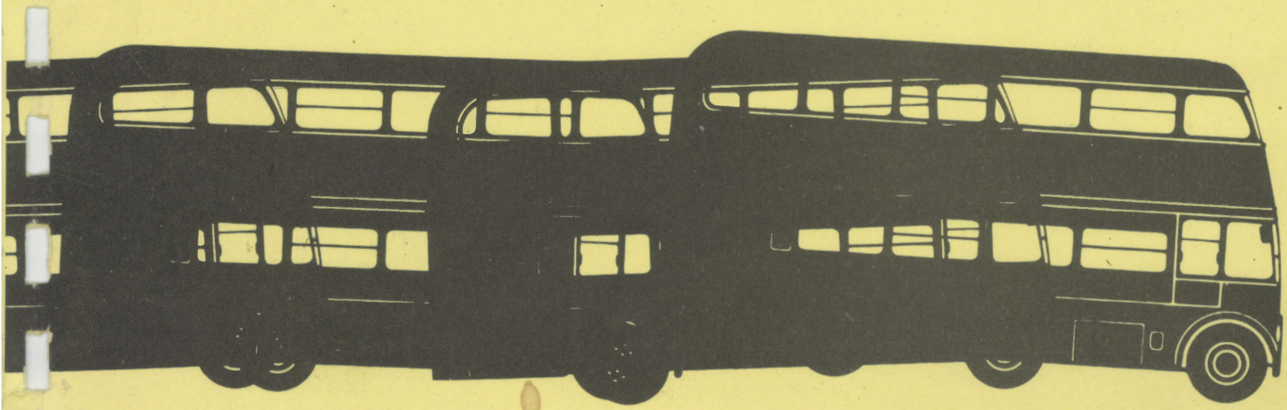
# HUMAN REACTION TO VIBRATION



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