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# HAND-ARM VIBRATION FROM AN INDUSTRIAL SANDER AND ITS HEALTH EFFECTS

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## INTRODUCTION

It is well known that the use of tools such as sanding machines can produce Vibration White Finger (VWF), and indeed VWF is a prescribed industrial disease. However, little is known of the dose-effect relationship of hand-arm vibration. Guidelines are published in Appendix A to BS6842, 'The British Standard Guide to the Measurement and Evaluation of Vibration Transmitted to the Hand'(1). However these are for information only and are not part of the Standard. This paper investigates a typical situation where VWF could be a problem.

A vibration survey was undertaken on the SECO 5B compressed air-fed sander at RAF St Athan. St Athan is a base where many types of aircraft undergo major refurbishment, including the complete strip down and repaint of external surfaces. The process includes the use of a chemical stripper to remove most of the paint. The sander is used to remove those paints resistant to chemical removal and to finish off the surface preparation process.

The employee is under stress from a number of different sources. An air-fed hood is worn to provide clean air, in conjunction with a light, disposable, boiler suit, because the solvent used to strip down an aircraft is potentialy hazardous. An aircraft has many different surfaces, and consequently a variety of postures have to be adopted, for example, for sanding underneath the wings and fuselage, which means the arms have to hold the sander in position.

## EQUIPMENT

Vibration levels were monitored using 3 B&K 4371 accelerometers, mounted in the 3 orthogonal axes. The output of these was then conditioned by B&K 2634 charge amplifiers and recorded by a digital acquisition system based on a GRID 1535 EXP portable pc. The digitisation rate was 5041 samples per second. The signal was low-pass filtered by 8 pole anti-aliasing filters, with a cut-off frequency of 1250 Hz. Subsequent analysis was carried out using a vibration analysis package called HVLab version 3.5.

## MEASUREMENT TECHNIQUE

The B&K accelerometers were mounted on the SECO sander as shown in figure 1.

Each accelerometer was screwed onto a B&K mechanical filter, in order to prevent the problem of d.c. shift in the signal. The filter and accelerometer assemblies were then screwed onto a small aluminium cube in the 3 orthogonal axes, which in turn was screwed to the side plate of the tool. All cables from the accelerometers were taped onto the body of the sander to prevent spurious vibrations occuring due to cable slap. Figure 2 shows a diagram of the whole measurement chain from accelerometer to portable computer.

Measurements were made within the spray bay of the paint shop at RAF St Athan. Unfortunately, measurements could not be taken of the sander being used to sand down a whole aircraft since, due to the fire hazard within the spray bay, only intrinsically safe instruments could be used.

A sequence of measurements were performed using various sanding techniques, these ranged from normal pressure, to light pressure, to heavy pressure. In addition, start-up and switch-off recordings were made to see whether the tool produced a significant kick.

## ANALYSIS

In order to calculate the frequency weighted r.m.s. acceleration produced by the sander, various operations were performed on the raw data files acquired. This chain of analysis is shown schematically in figure 3. The signal was frequency weighted in accordance with BS 6842, the filter shape used being shown in figure 4. To calculate the predominant frequency of vibration of the sander, the signal was normalised, then the power spectral density was obtained.

## RESULTS

Figures 5-7 and figures 8-10 show the time history plots and power spectral density plots respectively for each measurement axis, for normal sanding. Table 1 shows the freqency weighted r.m.s. acceleration tabulated against each sanding technique measured, for the 3 measurement axes.

TABLE 1

| SANDING TECHNIQUE | FREQUENCY WEIGHTED R.M.S. ACCELERATION ($m/s^2$) | | |
|---|---|---|---|
| | X AXIS | Y AXIS | Z AXIS |
| NORMAL | 20.2 | 25.6 | 18.2 |
| NORMAL | 23.6 | 25.6 | 18.2 |
| HEAVY | 17.0 | 21.9 | 14.8 |
| HEAVY | 27.5 | 27.0 | 17.8 |
| LIGHT | 21.0 | 25.2 | 19.6 |
| LIGHT | 21.9 | 25.6 | 17.3 |
| NORMAL | 15.2 | 20.6 | 12.0 |
| NORMAL START-UP | 15.1 | 20.3 | 16.3 |
| NORMAL SWITCH-OFF | 10.1 | 12.3 | 9.26 |
| NORMAL (10 SECS) | 19.1 | 22.8 | 17.1 |
| NORMAL (10 SECS) | 17.8 | 22.0 | 16.9 |

## DISCUSSION

Before measurements commenced, employees using the sander were observed sanding down a Tornado GR1. This was done in order to see the sorts of postures used when sanding down a whole aircraft. All manner of postures were observed, from standing on top of the aircraft sanding down the tailfin, to lying down on a moving platform underneath a wing.

Following consultation with the operators, it was ascertained that the sanders could be used for anything up to two weeks. This would involve them being used for 8 hours on the day shift, and 9.5 hours on the night shift. Out of a total of about 220 working days it is estimated that the sanders would be used for around 80 days.

Clearly, vibration is not the only consideration in this situation. Moreover, as the SECO sander is an industrial model it is quite weighty and it takes a lot of effort to keep it supported whilst sanding vertical surfaces. Therefore, using the sander for extended periods may lead to lactic acid build up in the arm and associated discomfort. Consequently, fatigue may be a factor which could give rise to increased susceptibility to Vibration White Finger.

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A frequency weighted r.m.s. acceleration of 2.8 $m/s^2$ endured for 8 hours a day may lead to symptoms of VWF in about 10% of the exposed after about 8 years according to BS 6842. However, during consultation with the medical officer he maintained that no cases of VWF had been reported to him. This implies that either the standard is too strict in this situation; the figure of 2.8 $m/s^2$ being derived from a survey of forestry workers working in cold environments, or the problem might not have shown itself up because the RAF employee is likely to get posted around frequently. With the sander producing an r.m.s. acceleration of approximately 26 $m/s^2$ as measured, and it being used for, on average, 80 days per year this would imply that finger blanching should be observed in 10% of the exposed population after about 3 years, the average duration of a posting.

## CONCLUSION

In this instance it was found that BS 6842 overestimates the risk due to hand transmitted vibration, as has been found by other workers (2,3,4) using the largely equivalent ISO 5349 (5). As so little is known about the dose-effect relationship of hand-arm vibration, it is hoped that the data given in this paper will contribute to the body of knowledge used when reviewing the standard. Meanwhile, to err on the side of safety, VWF screening is going to be carried out in conjunction with other essential screening which is currently undertaken on this class of worker.

## REFERENCES

(1) British Standards Institution "Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand." BS 6842 (1987).

(2) Tasker, E G: "Assessment of vibration levels associated with hand-held roadbreakers". Scandinavian Journal of Work, Environment & Health 1986; 12(4): 407-12.

(3) Bovergi M; Franzinelli A; Strambi F: "Prevalence of vibration-induced white finger and assessment of vibration exposure among travertine workers in Italy". International Archive of Occupational & Environmental Health 1988; 61(1-2): 25-34.

(4) Futatsuka M; Sakurai T; Ariizumi M: "Preliminary evaluation of dose-effect relationships for vibration white finger in Japan". International Archive of Occupational & Environmental Health 1984; 54(3): 201-21.

(5) International Organisation for Standardisation "Guidelines for the measurement and assessment of human response to hand-transmitted vibration". ISO 5349 (1986).

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ACCELEROMETER MOUNTINGS
ON SECO S2 SANDER

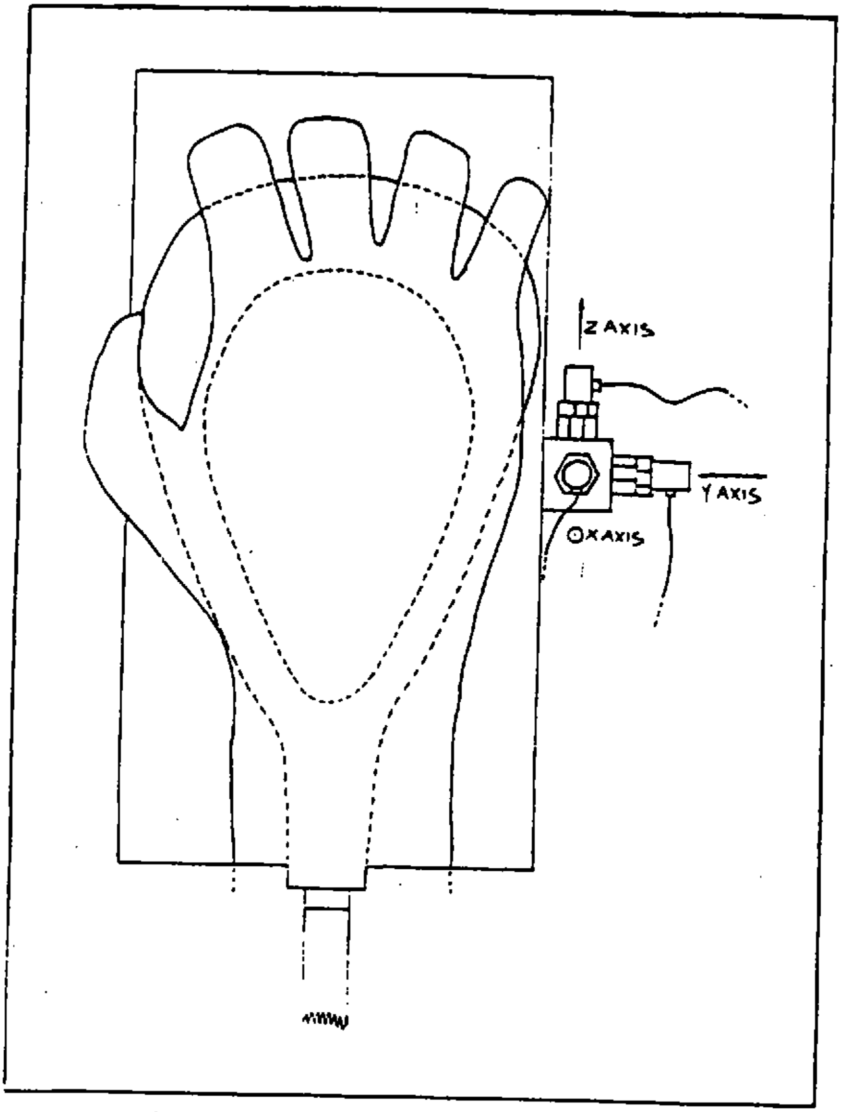
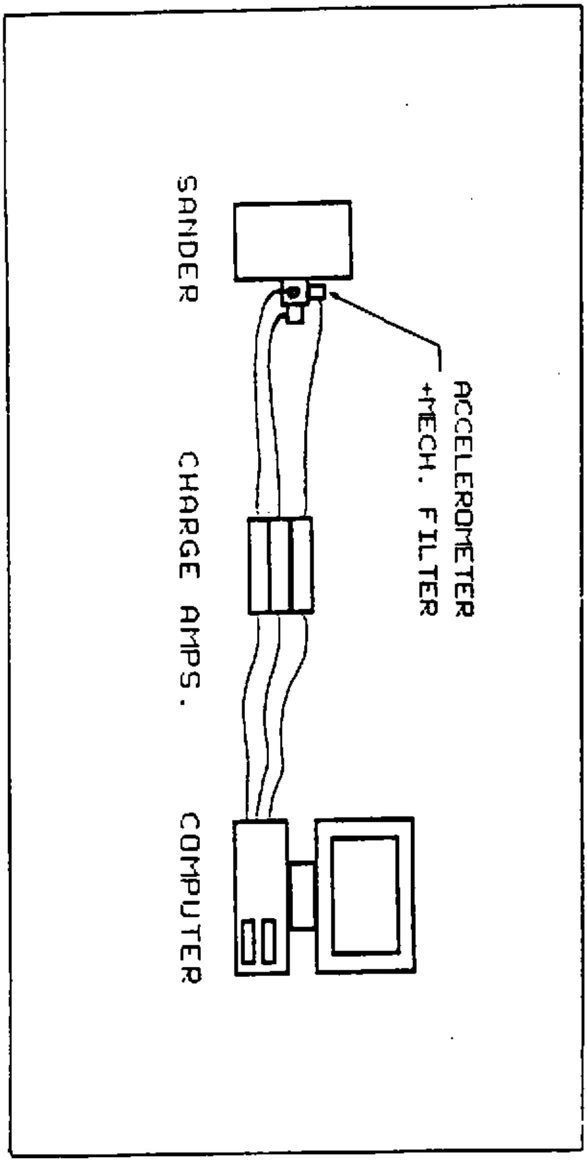



FIGURE 1




MEASUREMENT SYSTEM

FIGURE 2

STAGES OF ANALYSIS

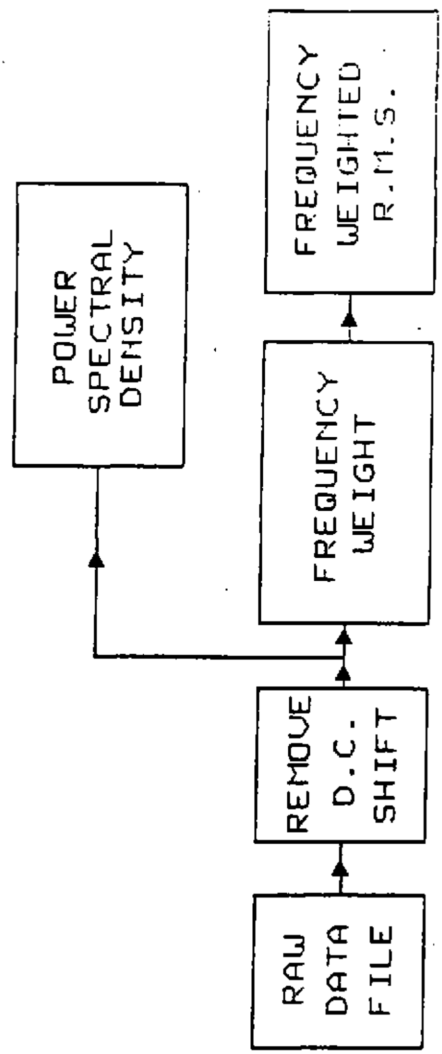
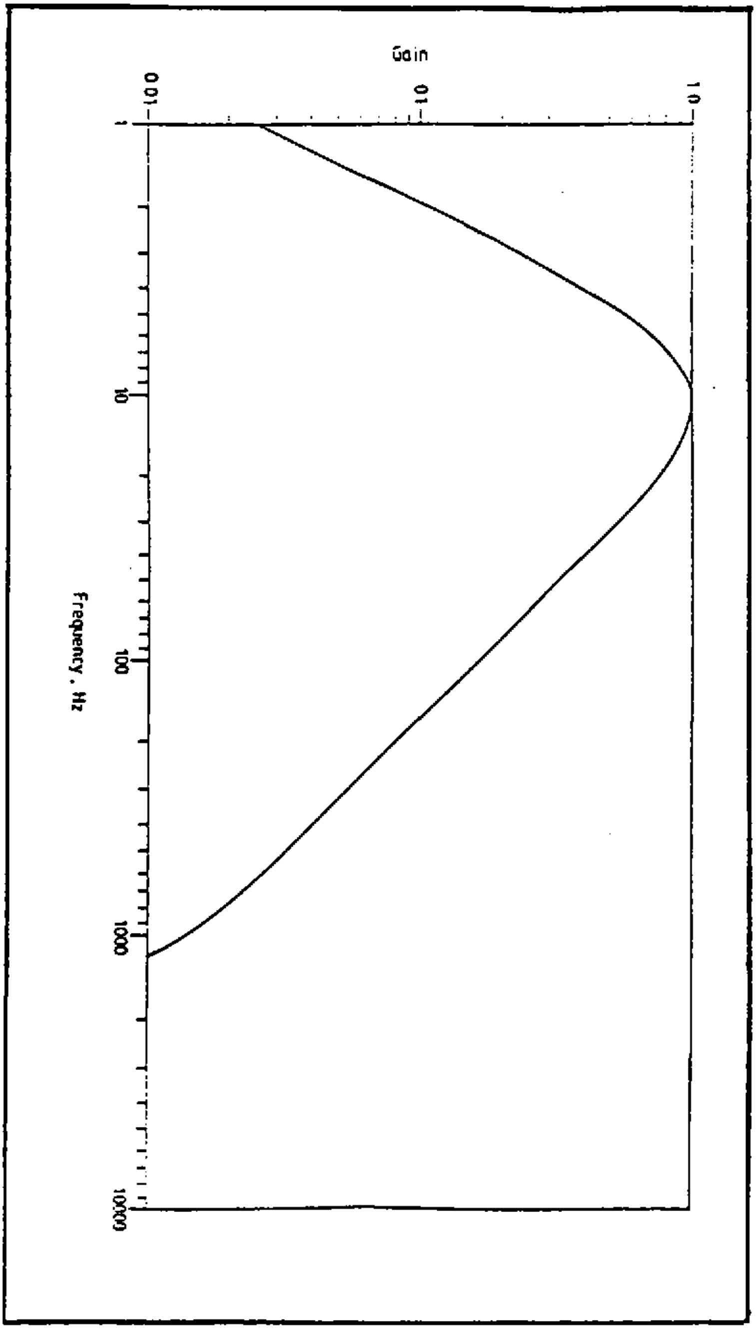



FIGURE 3




Modulus Of The Frequency Weighting $W_h$ With Band-Limiting Filters

FIGURE 4

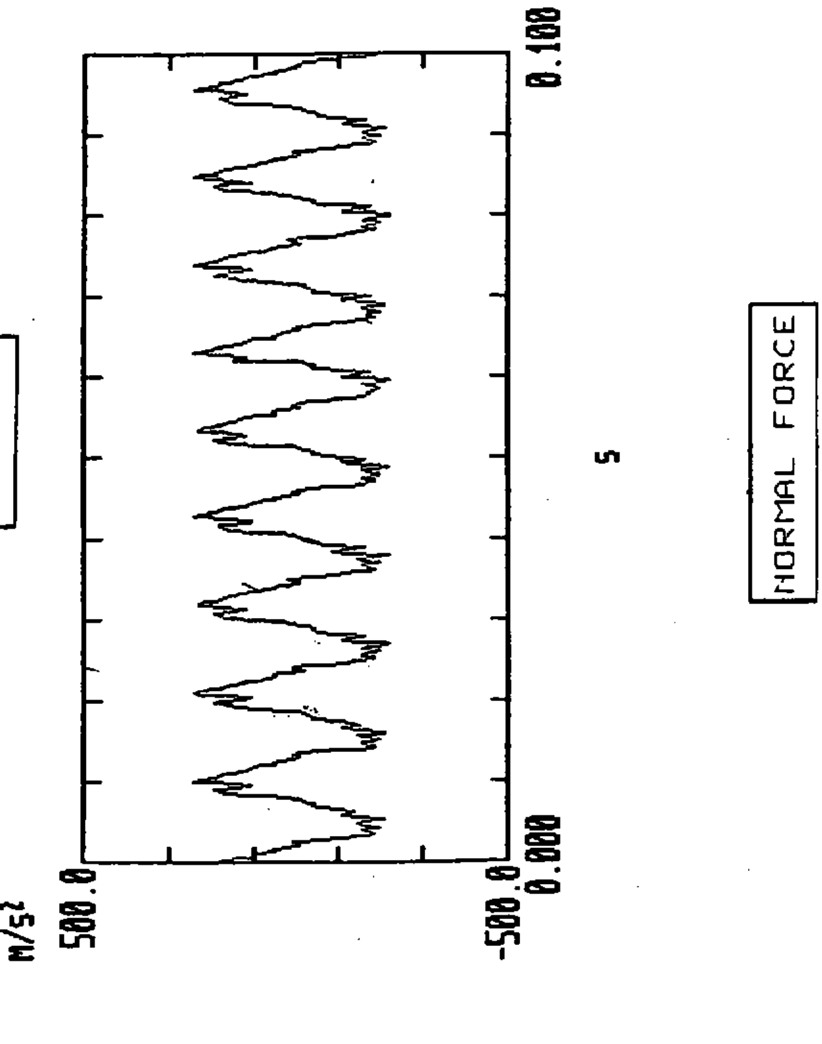



Fig 5

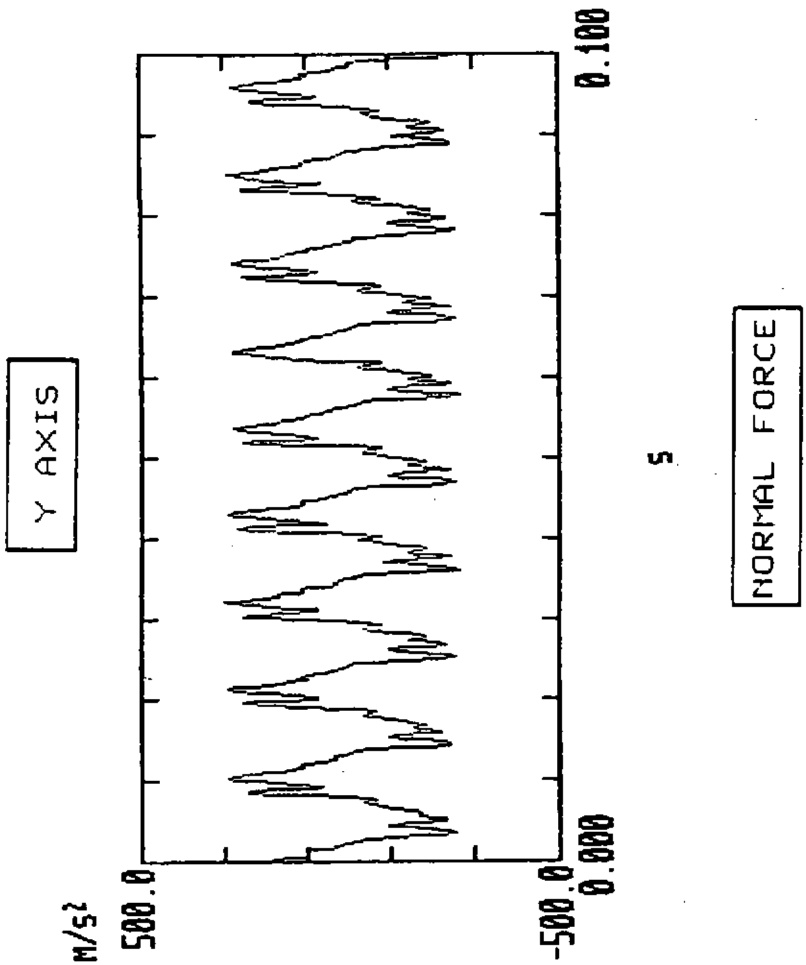



Fig 6

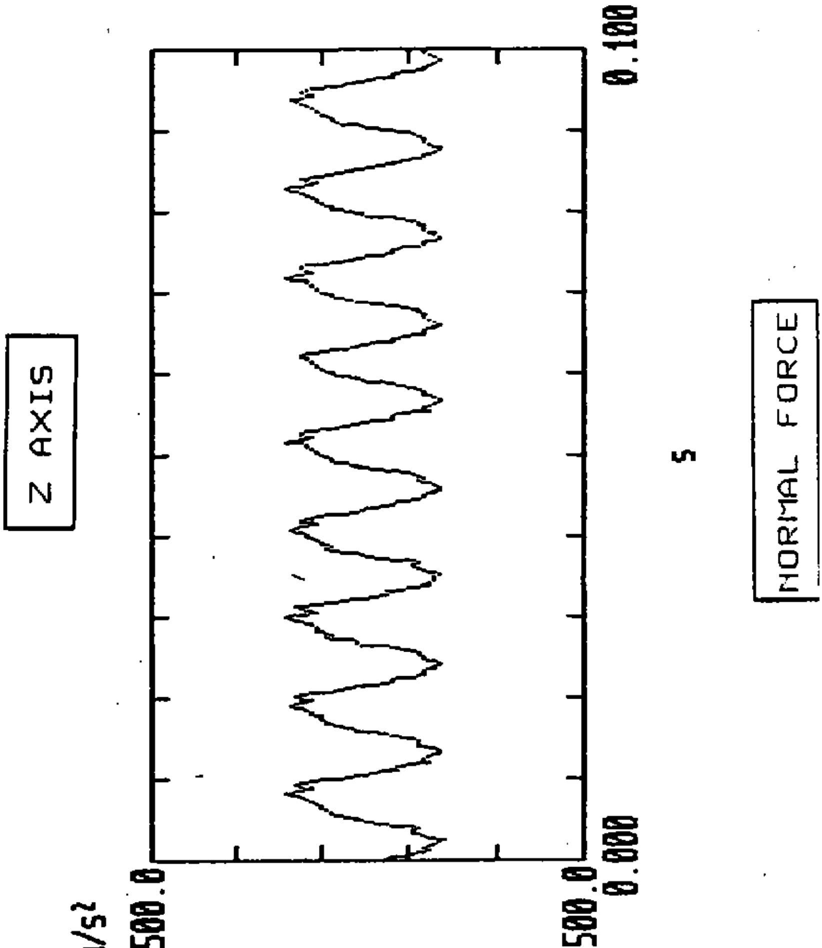



Fig 7

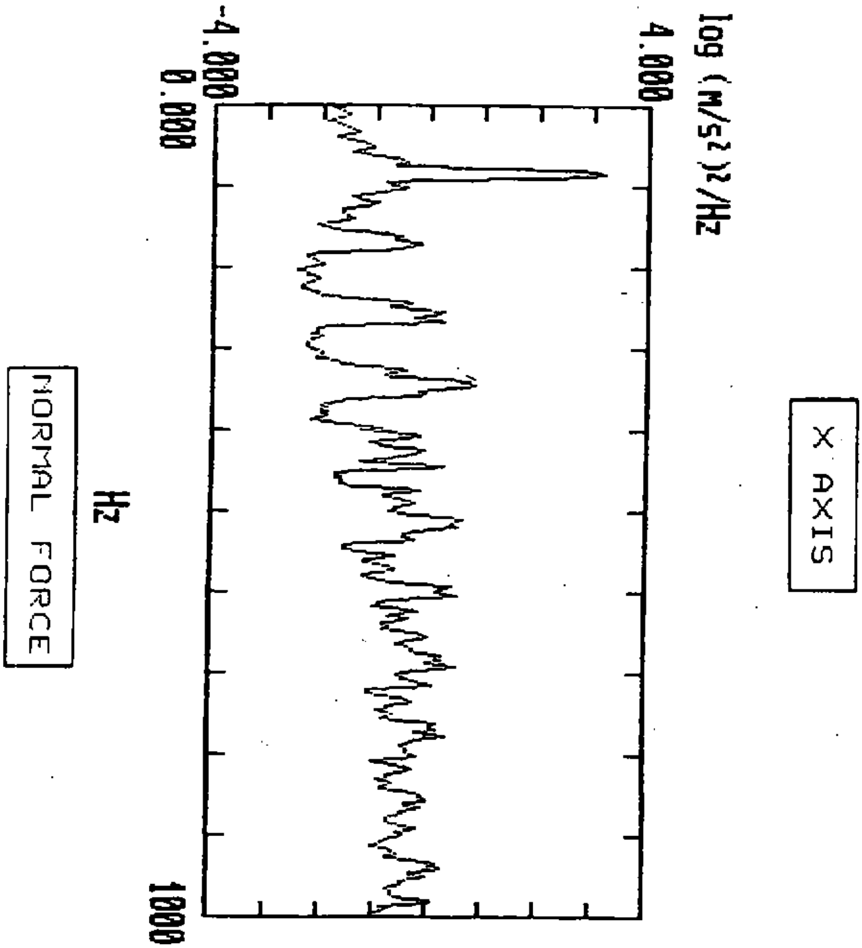



Fig 8

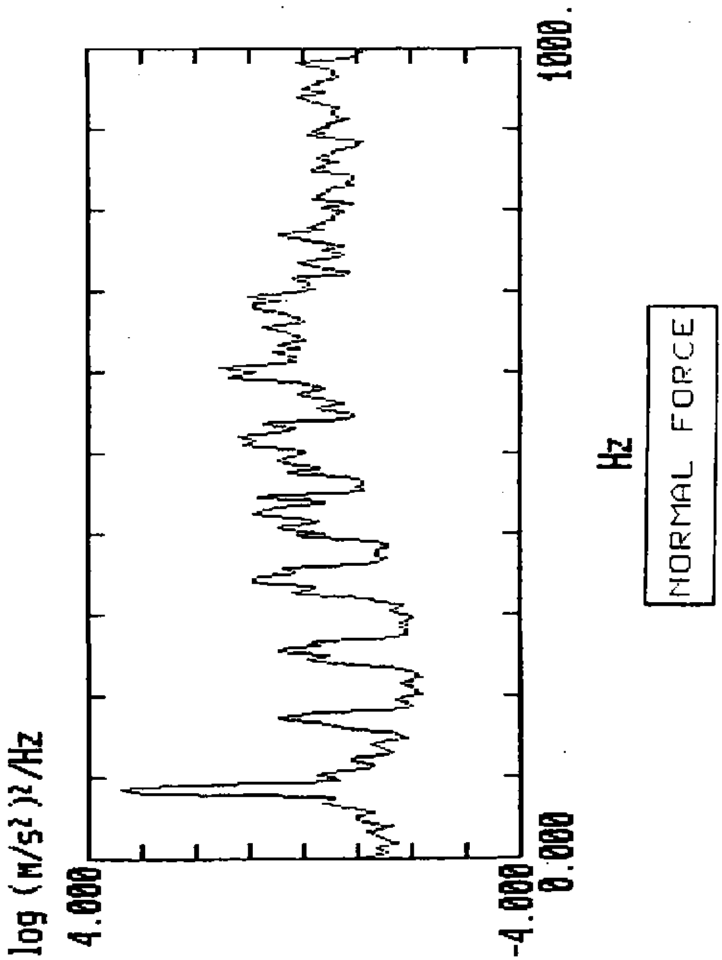



Fig 9

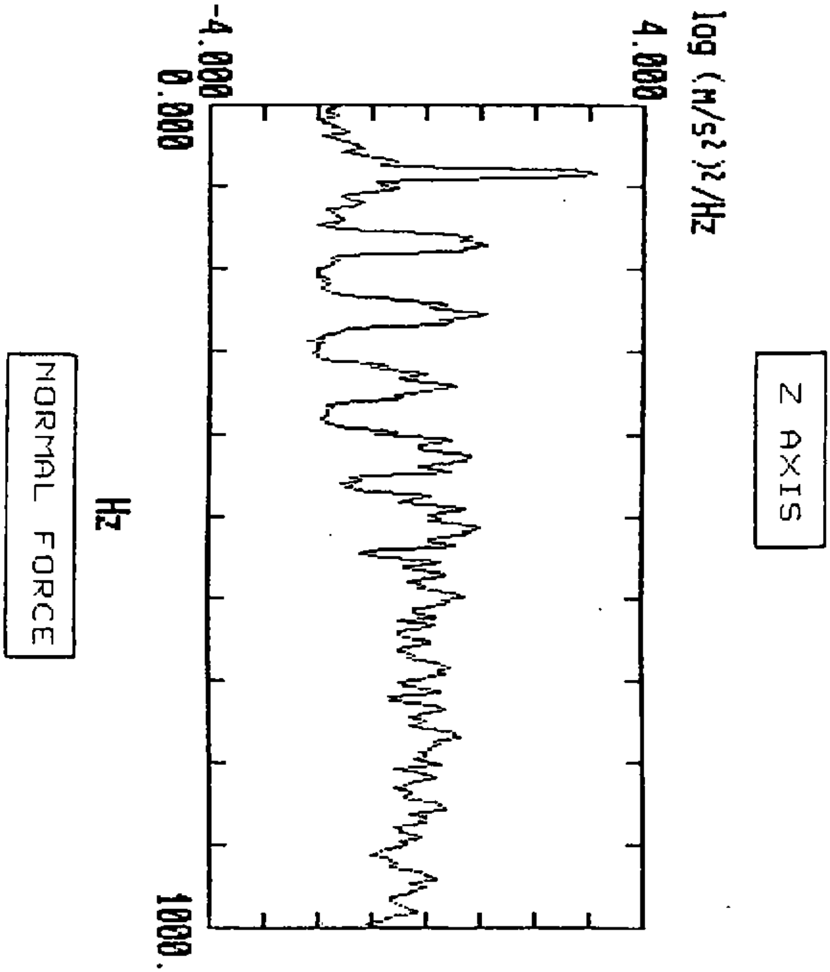



Fig 10