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THE RESPONSE OF HUMANS TO IMPACT NOISE.

by

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Introduction

Footfalls, typewriters, telex machines, punch card sorters and pneumatic hammers make impact noises which often become unacceptable to office users and flat dwellers. Several methods exist for the rating of continuous noise (dB(A), NC and NR curves and B.S.4142) but these do not adequately predict human response to impact noises (those having a fast rise time and exponential decay). In this respect the building industry is unable to design floors, walls and screen constructions which isolate impact noise with reasonable design tolerances. This paper describes an attempt to determine the physical parameters of recurrent impact noise which determine their loudness to human observers (so that designers can make a more appropriate allowance for impact noise when using present criteria).

The Experiment

The subject's task was to determine the loudness level of various impact noises. In each experiment he was seated in an anechoic room facing an electrostatic loudspeaker. Following a warning light alternate bursts of pure 1 kHz. tone, the reference signal, and impact noise were presented to the subject. Thirteen subjects, who were laboratory personnel with normal hearing, were asked to adjust the impact noise until it was "equal in loudness to the reference signal." The method of "equivalent stimuli" was used (Guilford, 1954). Impact sounds of 5, 10, 20, 40, and 100 p.p.s. repetition rate had to be matched in loudness to ten reference signals presented randomly and ranging in 5dB steps from 30-75 (r.m.s. level in dB re 2×10^{-5} N/m^2).

A block diagram of the apparatus is shown in figure 1. The impact sound having a rise time of 1 m.sec. and a decay time constant of 1.2 msecs. was generated with a pulse generator. It was fed to the external input of an audiometer set on the autobalance mechanism. This produced an output of alternate reference and impact signals of $\frac{3}{4}$ second duration. The tone and the impact noise could be adjusted independantly. The output was fed through an on/off switch and an amplifier to the loudspeaker in the anechoic room. The subject could speak to the experimenter through an intercom or relate his loudness decisions via a 3 light display panel in the control room.

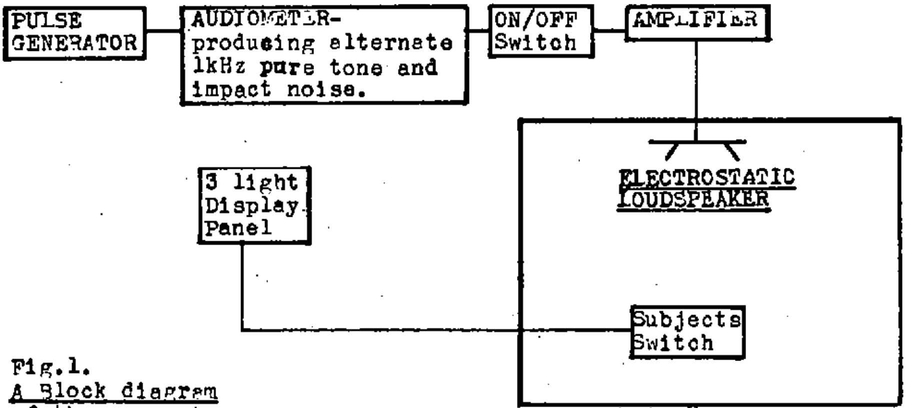

Fig.1.
A Block diagram of the apparatus.

Results.

The results are shown in figure 2. The pulse trains of equal loudness are plotted as a function of peak level and repetition rate. The level of the pure tone standard is the parameter, i.e. the phon. The within subject differences lie within the range ± 2.5 phons. However, the interpersonal differences were in the range ±11 phons for the low repetition rate and ±6 phons for the high repetition rates. The results in figure 2. are the mean values of a family of curves for 13 subjects.

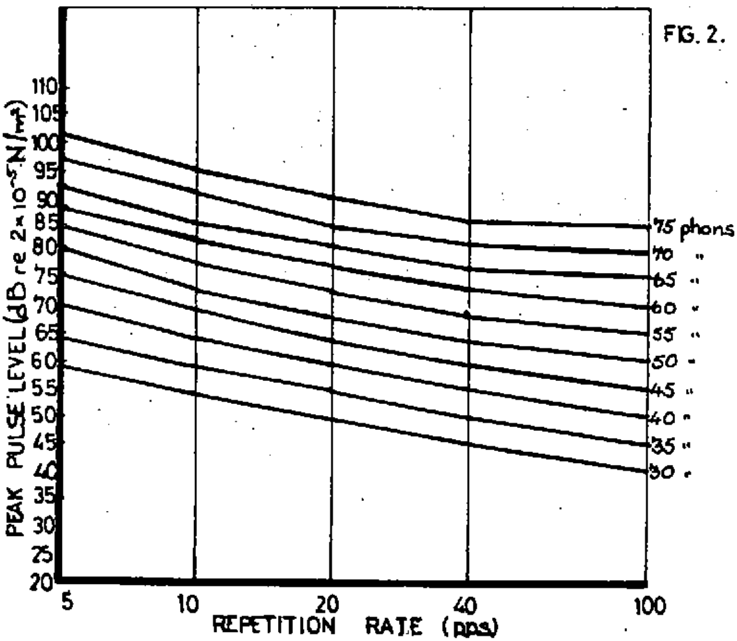

FIG. 2.

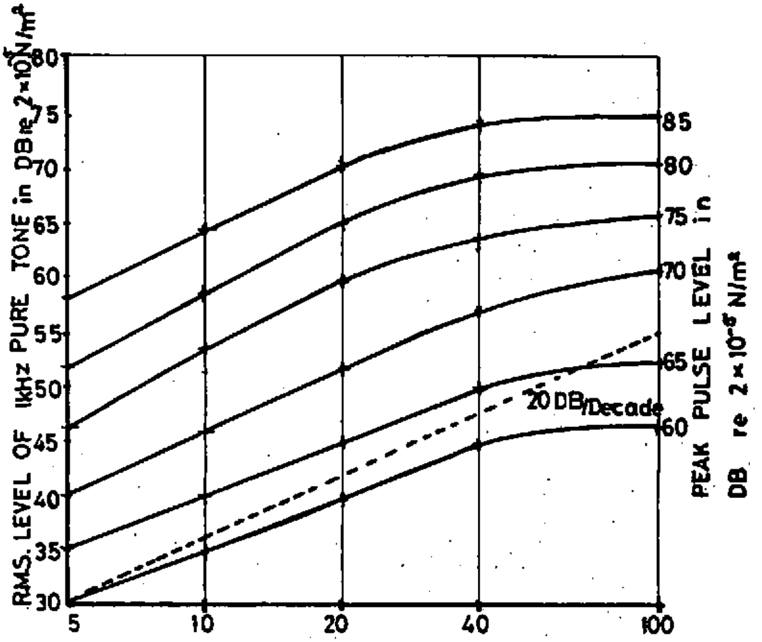

FIG. 3.

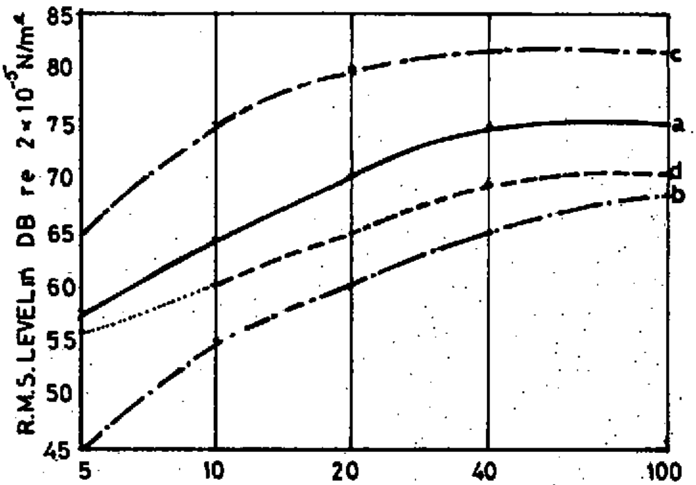

FIG. 4.

——a = phon curve of impact sound with peak pulse level of 85 DB re 2×10^{-5} N/m² for mean of 13 subjects.

·——-b = 0 percentile phon curve for same impact sound.

-—-—c = 100 " " " " " " "

......---d = the dB(A) reading on a standard meter conforming to B.S. 3489 with its dynamic characteristics are set to the 'slow' position (B.S. 4142:1967 pr.2.22)

Discussion

The shape of the curves in figure 2. seem to be comparable with similar work on impact noise of broad band spectra (Garrett, 1965) and triangular transients (Carter and Gallow, 1965).

In figure 3. the data has been transformed to show the growth of apparent loudness level of impact noise with repetition rate. The ordinate is a phon scale, while the abscissa is calibrated in pulses/second. In general over the range 5-20 p.p.s. the growth in loudness with repetition rate can be approximated to a straight line with a slope varying from 16.5 dB/ decade at the lower intensities and 24dB/decade at the higher intensities. Above 20 p.p.s. the curves tend to flatten out as the pulsed sound becomes progressively closer to continuous sound.

In figure 4. the phon curve for a typical impact sound, that for a peak pulse level of 85 dB, is plotted together with its 0 percentile and 100 percentile values. The equivalent dB(A) value (slow meter setting) for the relevant impact noise is also plotted. Although measurable, the meter reading for impact noise below 10p.p.s. is shown as a dotted line. Below this value limitations in the sensitivity of the meter prevent accurate measurement of impact noise. The dB(A) curve is approximately 5dB(A) below the mean* value and 15 dB(A) below the 100 percentile value of the apparent loudness curve.

In order to make an impact noise allowance for the community in general it would be more appropriate to compare the meter reading with the 95 percentile value and not the mean* or 50 percentile reading i.e. at least 95% of the subjects should be satisfied (Garrett, 1965). The 95%ile value is approximated by the upper curve in figure 4. (100%ile line.). Thus a more realistic allowance for impact noise would be 15dB(A) above the meter reading.

Conclusion

A determination of the loudness levels for impact noises of different repetition rates and pulse peak levels in dB has been carried out for 13 otologically normal observers. It has been suggested that 15dB(A), rather than 5dB(A), would be a more appropriate allowance for impact noise in the present design criteria.

*Reasons for plotting mean rather than median will be given at the conference.

References

1. Guilford, J.P., Psychometric Methods, McGraw-Hill, 1954.

2. Garrett, R.M., Journal. Sound Vib. (1965) 2 (1) 42-45.

3. Carter, N.L. & Gallow, R.P., J. Auditory Research. Vol 5. 1965 p.119-131.