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NOISE AND LOUDNESS EVALUATION

THE RESPONSE OF HUMANS TO RECURRENT IMPACT NOISE

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In the controlled environment of the laboratory psycho-acoustical experiments were carried out to find man's response to recurrent impact noise. In particular, loudness level contours of recurrent impact noise have been determined for a range of intensities, repetition rates, decay times and carrier signals. In 1971 Powell read a paper to the society illustrating the need for such a study, describing the physical characteristics of impact noise encountered in practice and discussing an early pilot study. This paper attempts to describe the progress since that time.

THE PRESENT INVESTIGATION

The task of the subject was to estimate loudness levels of various impact noises. In each experiment he was seated in an anechoic room facing an electrostatic loud-speaker. When a 'thank you/warning' light in his display panel went out, alternate bursts of 1kHz pure tone, the reference signal, and impact noise were presented to him. Twenty 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. They did this using the 'double staircase method' described fully by Cornsweet (1962). During the experiment the subjects related their loudness judgements to the experimenter by a means of switches on their control panel. These switches actuated lights in the control room which instructed the experimenter to increase or decrease the level by gradually diminishing amounts.

The Experimental Plan

There were three test series:-

Series One-In the first series of tests ten subjects judged the 40, 60 and 80 phon loudness levels of

* The research involved in this paper was carried out while the author was a member of the Acoustics Group of the University of Salford, under the aegis of Professor Peter Lord.

recurrent impact noises with the carrier set to frequencies of o.5,1,2,3,4,5,6 and 7 kHz.All nine impact noise parameter combinations of repetiton rates 5,20 and 100 with decay rates 2,9.5 and 28 ms were tested.

Series Two-Twenty subjects judged the 40,45,50,55, 60,65,70,75 and 80 phon loudness levels of recurrent impact noises with the carrier set to a frequency of 4 kHz.All possible combinations of the following impact noise parameters were tested:-

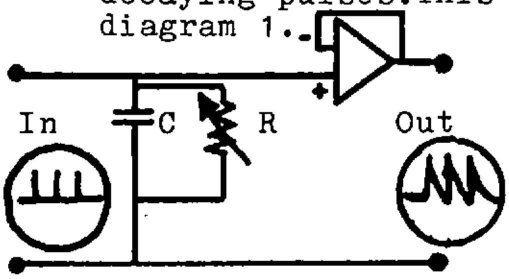
Rise time (ms) = 1
Repetition
Rate (i.p.s.) = 5,10,20,40 and 100
Decay Time (ms) = 2.2,5.8,9.5,18 and 28

Series Three-Twenty subjects judged the 40,50,60 and 70 phon loudness levels of recurrent impact noises having a 1ms rise time and a white noise carrier. Combinations of repetiton rates and decay times tested were:-

Repetition Rate i.p.s.	Decay Time ms	Repetition Rate i.p.s.	Decay Time ms
5	2.2	20	9.5
5	9.5	20	28.0
5	28.0	20	100.0
5	100.0	40	2.2
10	2.2	40	28.0
10	28.0	100	2.2
10	100.0	100	9.5
20	2.2	100	28.0

Stimulus Generation and Presentation

The Recurrent Impact Noises- A series of narrow spikes produced by an Aim Electronic Modular Pulse Generator Type S.6 were modified by means of a variable shaping circuit to produce exponentially decaying pulses.This shaping circuit is shown in diagram 1..



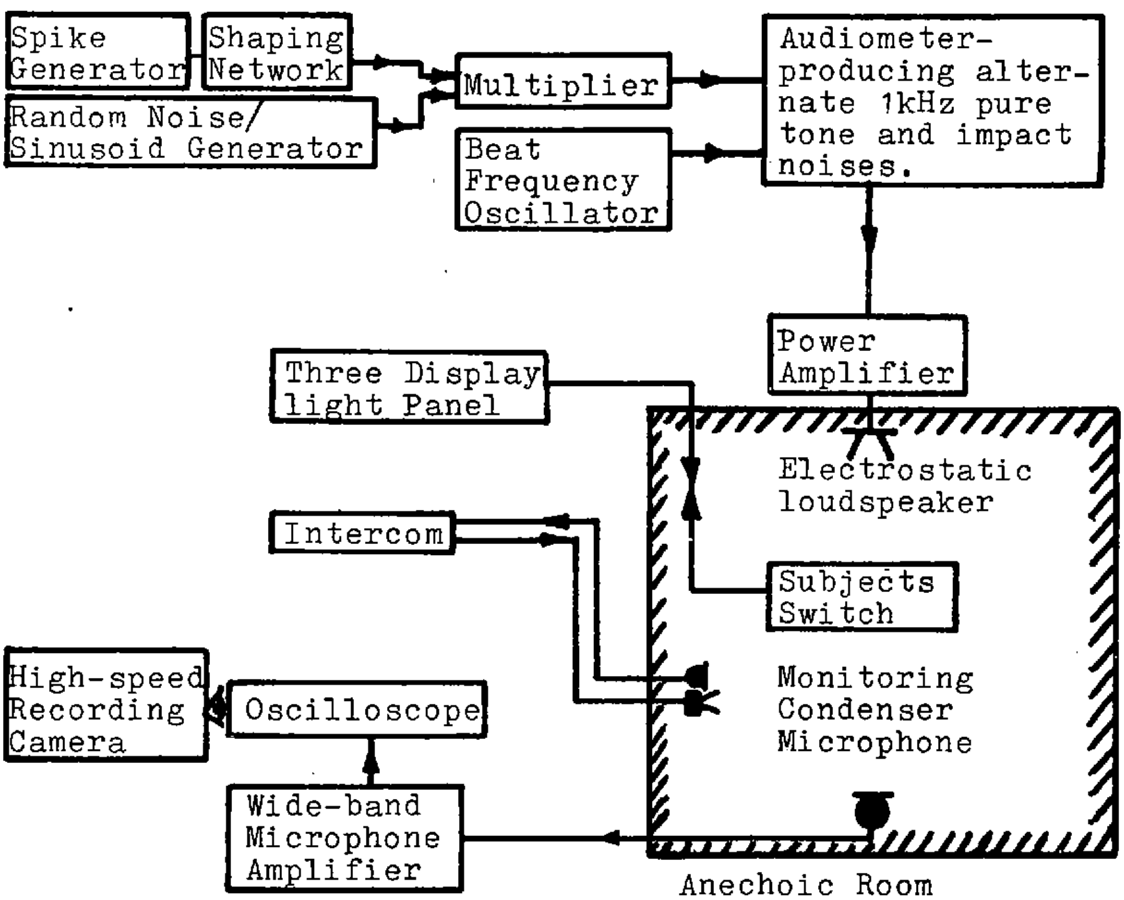
This is a modified peak memory circuit.The decay time of the pulses can be altered by means of the variable resistance R which controls the leakage current across capacitor C

Diagram 1. Variable Shaping Network

The pulses produced by this shaping network were used in conjunction with an analogue multiplying device to modulate white noise and pure tones, themselves generated by a B and K Sine Random Generator Type 1024.The resulting pulses are either exponentially decaying sinusoids or white noise. Electronic simulation of the impact noises enabled the researcher to alter the parameters of the noise

signals quickly and accurately.
The Standard 1kHz Pure Tone-This was generated using a B and K Beat Frequency Oscillator Type 1022.

The recurrent impact noises and the pure tone were fed into the electronic switching mechanism (autobalance setting) of a Peters Audiometer Type AP6.This produced an output of alternate reference and impact signal.The tone and the impact signal could be adjusted independantly using the separate'reference'and'test' attenuators of the audiometer.The attenuators had a range of 110dB in 1 decibel steps.For final amplification the signal was fed through a Quod 303 power amplifier to a Quod Electrostatic loudspeaker in an anechoic room.A block diagram of the apparatus is shown below.



A Block Diagram of the Apparatus

Summary Results and Conclusions

As space is short here it is considered better to summarise briefly the essential relations found in the work to date and leave the discussion of the findings until the day of the conference.All the following statements can only be considered to hold over the range of the parameters studied in the research:-

1. The Effect of Carrier Frequency on Loudness Level.
It is clear that loudness level of recurrent impact noise is dependant on the frequency of the carrier signal.
Loudness Levels of such noises vary as a function of the carrier signal in a similar way to the loudness levels of "steady" pure tones.

2. The Effect of Repetition Rate on Loudness Level.
It is clear that as repetition rate increases the peak height necessary to maintain equal loudness is reduced. In other word, the loudness level of impact noise increases with repetition rate.
In the range up to 20 i.p.s. the growth in loudness level with repetition rate can be approximated by a straight line varying in slope between 3.25 and 4.0 phon per doubling of repetition rate. The larger increase is associated with the shorter decay time.
In general above 20 i.p.s. the curves tend to flatten out as the impact pulse chains perceptually change into continuous noise. For long decay times, 100ms, this flattening out occurs at 10 i.p.s.

3. The Effect of Decay Time on Loudness Level.
It is clear that as duration of decay time increases the peak height necessary to maintain equal loudness is reduced. We may say, then, that the loudness level of recurrent impact noise increases with duration of the decay time.
In the range up to 20 i.p.s. the growth in loudness level with decay time can be approximated by a straight line of slope 3 phon per doubling of decay time.
In general above a repetition rate of 20 i.p.s. and a decay time of 10 ms this linear relationship breaks down and is replaced by a curve; once again the impact noise is tending to be perceived as a continuous noise.

4. The Effect of Peak Height on Loudness Level.
A doubling of the peak height of an impact noise increases its loudness level by approximately 6 phons.

References

1. Cornsweet, T.N., The Staircase Method in Psychophysics. American Journal of Psychology. Vol 75 1962, pp485-91.

2. Powell, J.A., Human Response to Impact Noise, Chapter 10 in Building Acoustics, Edited by T. Smith, P.E. O'Sullivan, B. Oakes and R.B. Conn, Oriel Press, 1971, British Acoustical Society Special Volume Number 2.