PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

Improvement of copy machine noise

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ABSTRACT

We use copy machine in our daily life for the output of hard copy of our manuscripts which is usually connected to PC. As a copy machine is usually located close to the user, it is important to improve the noise emitted from the machine for good sound atmosphere. When we think of the noise emitted from the copy machine for good sound atmosphere, there are several causes that create unwanted sound from the machine. Here we would like to show you the result of the improvement of noise emitted from copy machine by treating the time envelope of the noise for better impression. Together with this, various background noises were superimposed to the copy machine noises, one for the original and the other for the improved to show the treatment to the original copy machine noise makes this sound rarely identified its existence with the increased sound level compared with the original machine noise.

Keywords: Improvement, Copy Machine Noise, Time envelope signal, Background Noise

1. INTRODUCTION

This study deals with the copy machine noise for make it more desirable to perceive it under real atmosphere, namely machine noises exist with background noise. The existence of background noise covers the machine noise as the masker sound to some extent. The copy machine noise we treat here is the hopper noise(1). The hopper is the machine operating mechanism integrated inside the copy machine in order to make the toner surface flatter for better print out. For this purpose, the hopper moves between silent time period intermittently with time and the noise created for flattening the toner surface make us feel disturbed because of the sudden happening of noise under silent atmosphere. The time signal pattern of the hopper sound is a chain of single impulsive sound event with rather steep rise and short fall and this envelop makes us feel more impulsive due to our hearing system. For this sound more acceptable than as it is, the rise and fall times of the single event will be treated for better impression. The practical procedure will be shown below

2. TREATMENT OF NOISE FOR BETTER IMPRESSION

The main cause of the hopper sound is the impulsive phenomenon happened at the contact position of the exciter and the hopper follower. Due to the impulsive touch between the exciter and follower, toner inside the hopper is flattened its surface due to the vibration caused by the exciter and the toner is distributed to the toner output area smoothly. But due to this motion, we hear an impulsive sound continuously and it make us feel annoying.

2.1 Effect of rise time variation to perception

The original time wave form of the hopper sound is shown in Figure 1. According to this figure, rise time of the hopper sound is approximately 8ms and its fall time is about 38ms. It means that this sound is a short duration impulsive sound. So, our perception on the sound is governed by its envelope wave form to some extent. In order to see the effect of variation of rise time, rise time of this signal is varied artificially from the original condition to 48ms in 5ms steps, namely, the rise times introduced are 8, 13, 18, 23, 28, 33, 38, 43 and 48ms respectively. The schematic representation of the wave forms are

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shown in Figures-2a. to 2h.

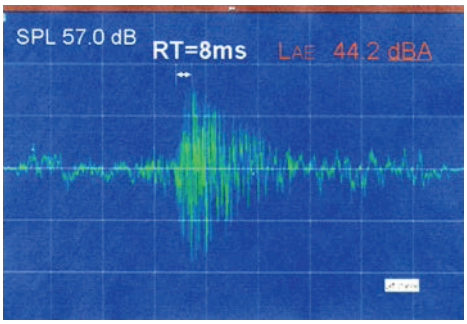

Figure-1 Original hopper sound

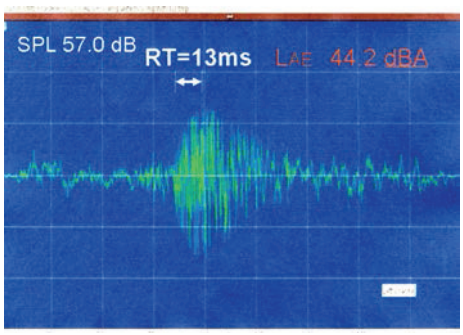

Figure-2a rise time +5ms

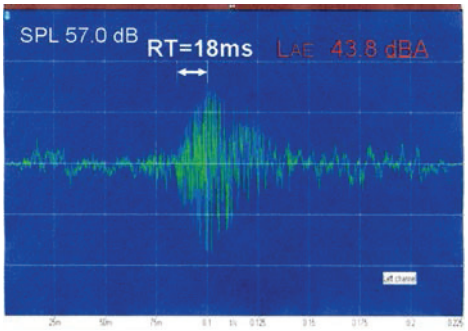

Figure-2b rise time +10ms

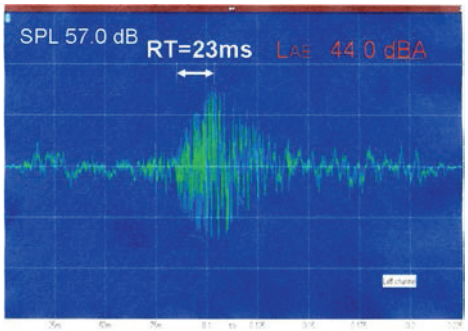

Figure-2c rise time +15ms

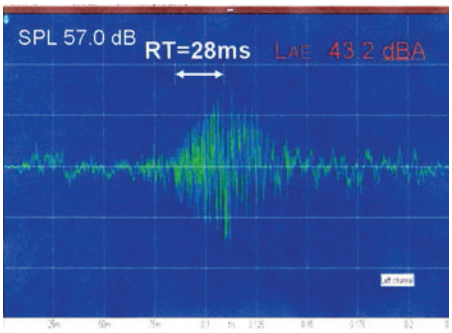

Figure-2d rise time +20ms

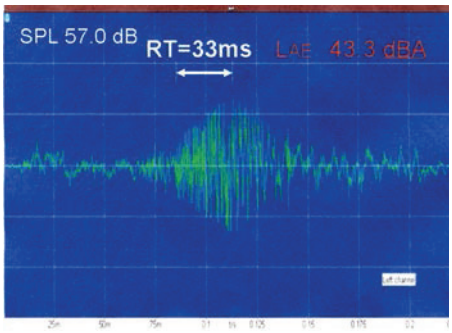

Figure-2e rise time +25ms

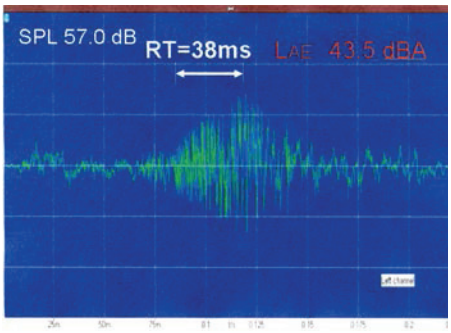

Figure-2f rise time +30ms

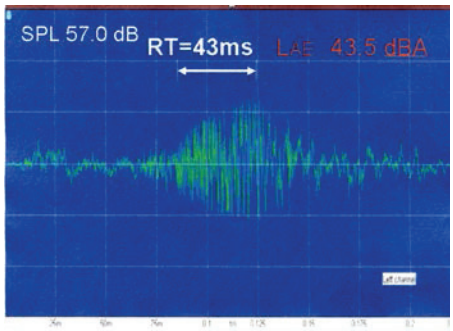

Figure-2g rise time +35ms

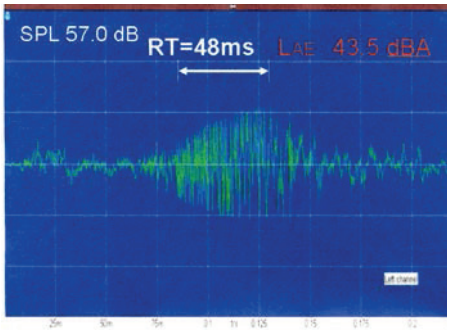

Figure-2h rise time +40ms

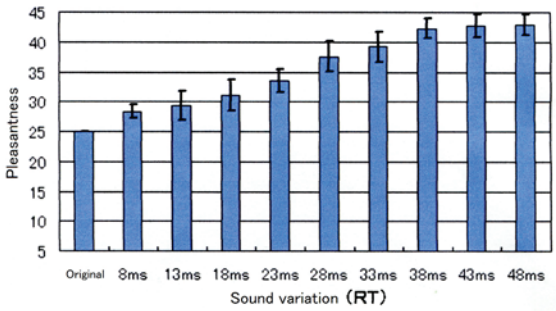

Figure-3 result of evaluation on pleasantness

: Effect of rise time variation

The sounds modified its rise time including original are tested for its pleasantness by pair comparison method, namely, each sounds are compared their pleasantness by the sound pair step by step. The numbers of the subject participated this experiment are 11 males and 2 females aged between 22 and 61 with normal hearings. The result was shown in Figure-3 when the LAE of the test sounds are set equal to 43.5 dBA. According to the result shown in Figure-3, the test sounds becomes more and more pleasant by the increase of rise time, namely, the test sound becomes less impulsive in impression and this makes the subjects feel the test sound pleasant. When the test sound is short and the rise time is short, the impression of the test sound is more impulsive with the shorter rise time and this makes the sound unpleasant.

2.2 Effect of fall time variation to perception

Next thing to see is the effect of variation of fall time of the hopper sound. As like the variation of rise time, fall time is varied from the original condition, namely, 42ms to 112ms in 10ms step. So the variations are, 42, 52, 62, 72, 82, 92, 102 and 112ms respectively. During the variation of fall time, the rise time of the test sounds are fixed at 38ms due to the result obtained in the previous experiment. The impression of pleasantness remains unchanged when the rise time is over 38ms. And the LAE of the test sounds are set equal to 43.5 dBA as is the same for previous experiment for the effect of rise time. The schematic representation of the test sounds are shown in Figures 4a to 4h.

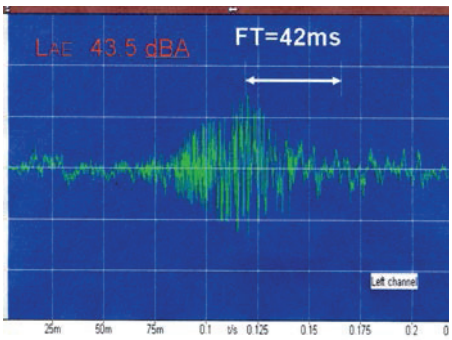

Figure-4a original condition: 42ms

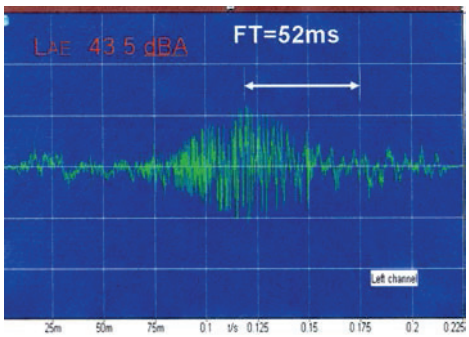

Figure-4b fall time +10ms

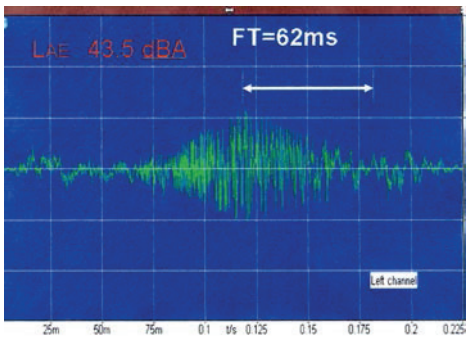

Figure-4c fall time +20ms

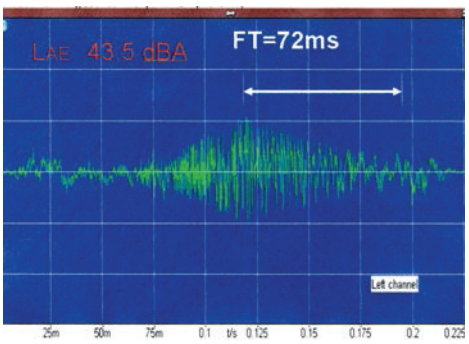

Figure-4d fall time +30ms

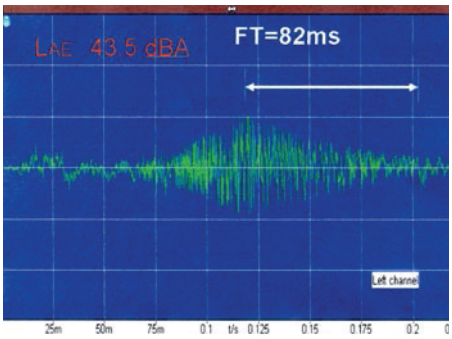

Figure-4e fall time +40ms

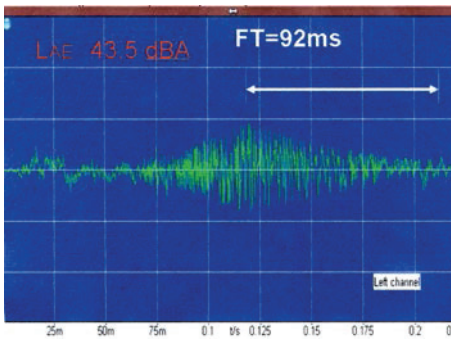

Figure-4f fall time +50ms

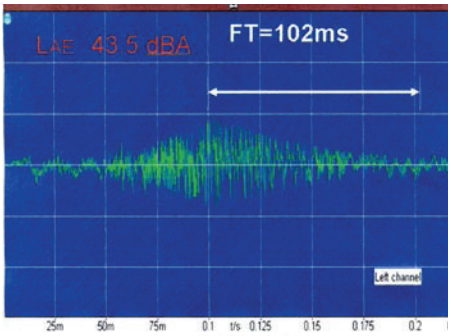

Figure-4g fall time +60ms

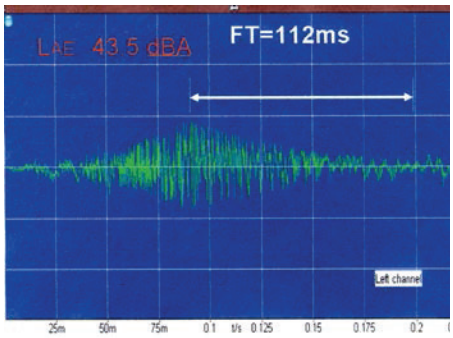

Figure-4h fall time +70ms

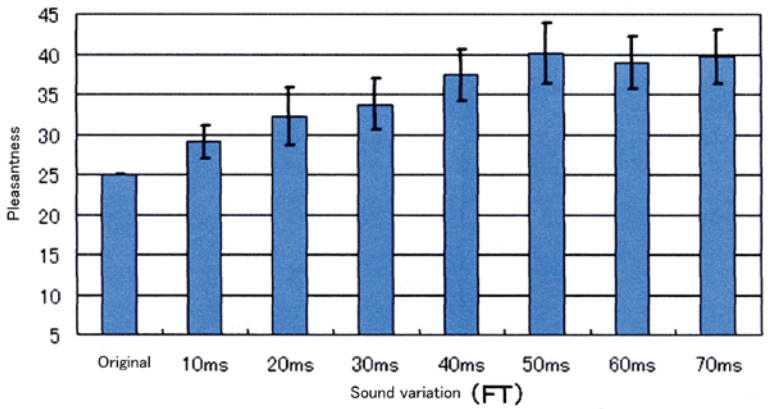

Figure-5 Reslut of pleasantness due to the variation of fall time of the hopper sound

The numbers of the variation in fall time starting from its original value, i.e. 42ms up to 112ms with 10ms increase in each step are 8 while the rise time of the stimuli is fixed at 38ms. These stimuli are used for testing their pleasantness by pair comparison method. Numbers of the subjects participated this experiment is the same as the previous experiment for rise time, namely, 11males and two females with normal hearing aged between 22 to 61 years.

The result was shown in Figure-5. The pleasantness of the sound increases with the increase of fall time up to the addition of 50ms compared with the original condition. In this case, real fall time is 92ms. Our perception on pleasantness does not change beyond this value. So, the optimum variation of original hopper sound is to set rise time at 32ms and fall time as 92ms for pleasantness. The test sound with this condition is defined as the modified sound compared with the original hopper sound.

3. VERIFICATION OF THE EFFECT OF VARIATION FOR IMPROVEMENT

3.1 Effect of masking under the existence of background noise

As is usual that a printer is set inside the room for its use and there exists background noise without any relation if the printer is working or sleeping according to the usage of the room. So when the printer under consideration is working, it is natural that the background noise is superimposed with the printer noise when person inside the room hear the printer noise. Our purpose here is to see the treatment effect with the printer noise, to what degree modified printer noise is masked by the background noise compared with its original printer noise. If the S/N ratio defined by the ratio value of printer noise as the numerator and background noise is denominator takes higher value with the modified noise compared with the original printer noise, then modified noise has improved effect that under the existence of background noise, the presence of printer noise is hard to hear..

3.2 Various background noise spectrum

In order to see the effect of masking under the existence of background noise for original and modified printer noise, various background noises are corrected. The background noise corrected are those recorded inside the usual living room, student cafeteria, library, and noise in front of air conditioner, mechanical fun noise emitted from PC, flow noise near the duct of an air conditioner, fun noise emitted from LC projector and artificial pink noise. The spectrum profiles of these sounds were shown in the following figures.

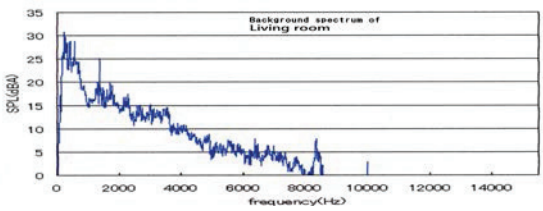

Figure-6a Background noise of living room

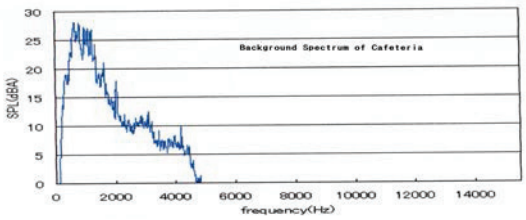

Figure-6b Background noise of cafeteria

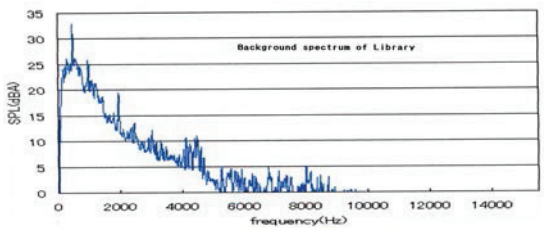

Figure-6c Background noise of Library

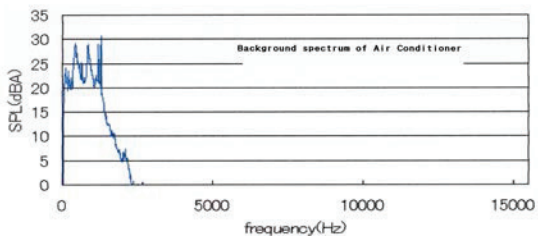

Figure-6d Background noise of airconditioner Fan noise

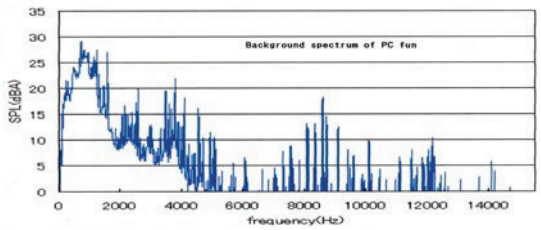

Figure-6e Background noise of PC fan

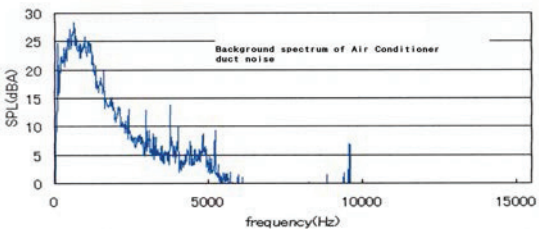

Figure-6f Background noise of Airconditioner Duct noise

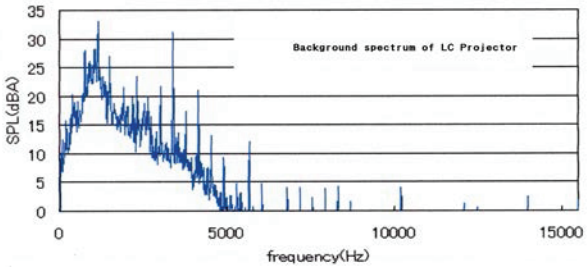

Figure-6g Background noise of LC projector

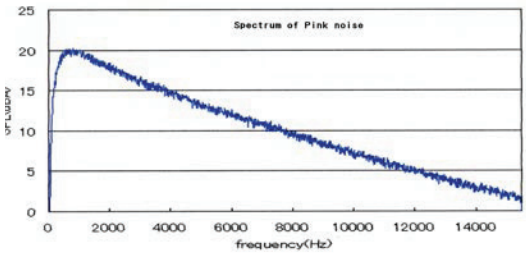

Figure-6h Pink noise

In order to test the capability for masking by various noises for the printer noise one for the original and the other for modified, background noise shown above are superimposed to the two kinds of printer noises while the level of the background noise is kept constant at 43.3 dBA. After the superimposition of background noise, the capability of hearing under the existence of background noise while the printer noise level is varied for its detectability was conducted. The results were shown in the following figures. The numbers of the subject participated this experiment are the same as the previous experiments, namely, 11 males and 2 females.

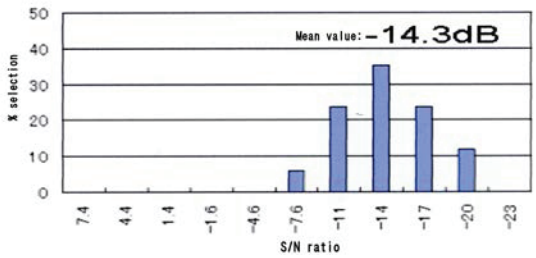

Figure-7a1 Result of just detectable level for the living room noise in case of original printer noise

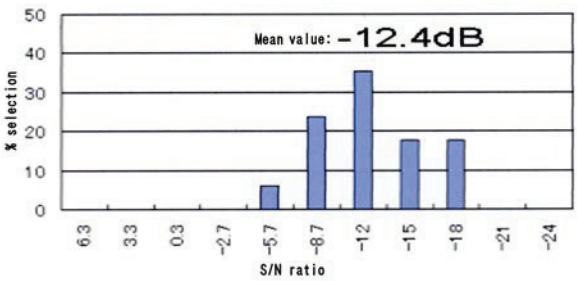

Figure-7a2 Result of just detectable level for the livingroom noise in case of modified

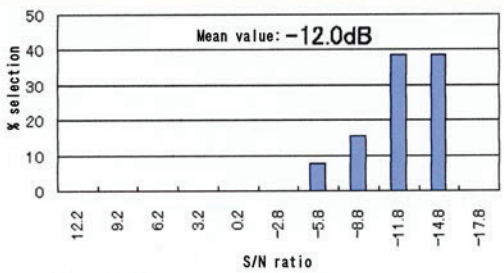

Figure-7b1 Result of just detectable level for the cafeteria noise in case of original printer noise

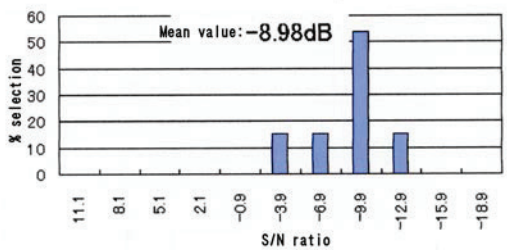

Figure-7b2 Result of just detectable level for the cafeteria noise in case of original printer noise

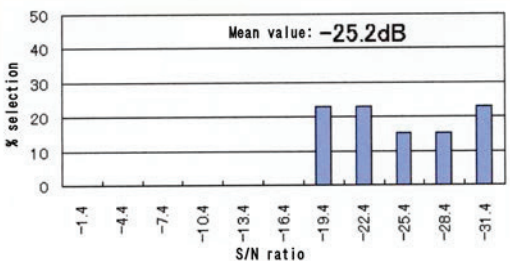

Figure-7c1 Result of just detectable level for the library noise in case of original printer noise

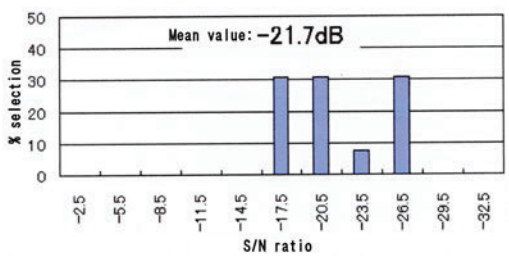

Figure-7c2 Result of just detectable level for the library noise in case of original printer noise

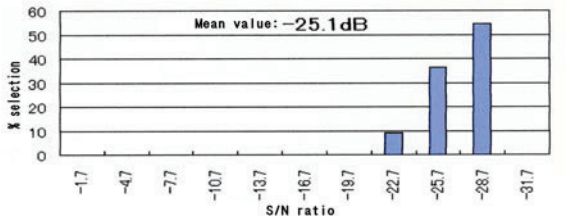

Figure-7d1 Result of just detectable level for the air conditioner fan noise in case of original printer noise

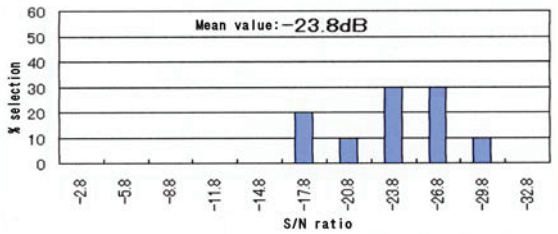

Figure-7d2 Result of just detectable level for the air conditioner fan noise in case of original printer noise

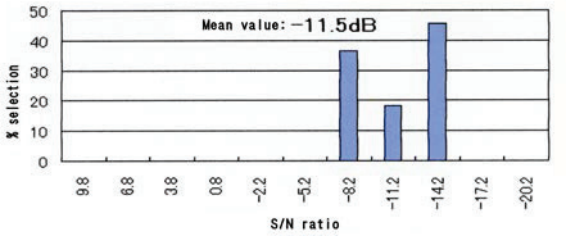

Figure-7e1 Result of just detectable level for the PC fan noise in case of original printer noise

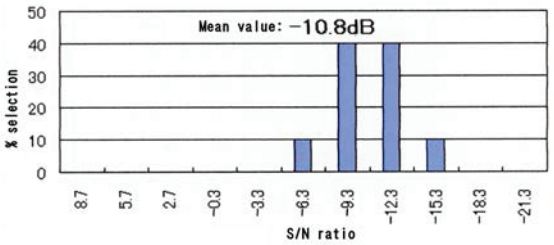

Figure-7e2 Result of just detectable level for the PC fan noise in case of original printer noise

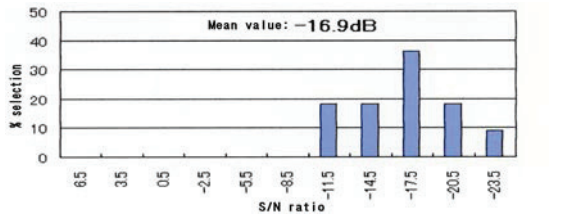

Figure-7f1 Result of just detectable level for the air conditioner duct noise in case of original printer noise

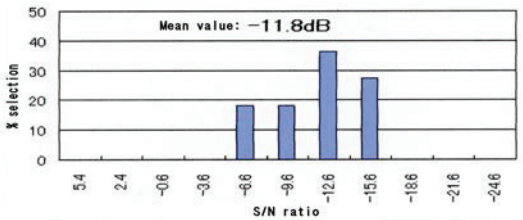

Figure-7f2 Result of just detectable level for the air conditioner duct noise in case of original printer noise

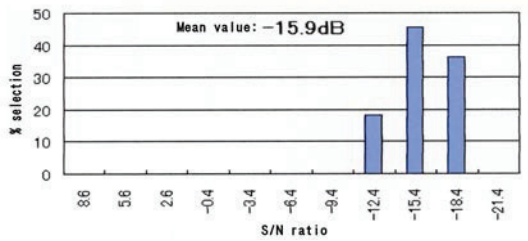

Figure-7g1 Result of just detectable level for the RC projector fan noise in case of original printer noise

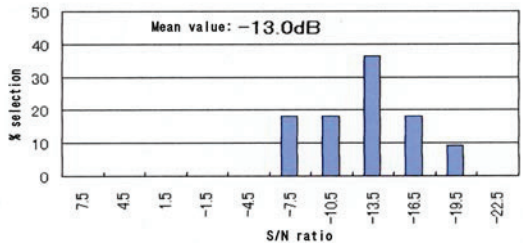

Figure-7g2 Result of just detectable level for the RC projector fan noise in case of original printer noise

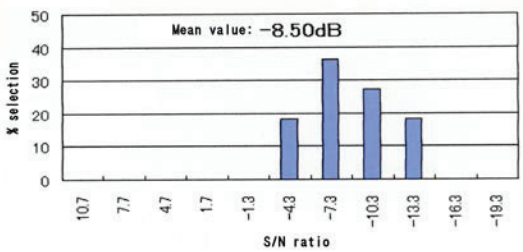

Figure-7h1 Result of just detectable level for the pink noise in case of original printer noise

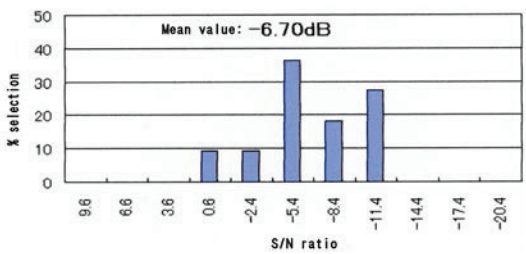

Figure-7h2 Result of just detectable level for the pink noise in case of original printer noise

From Figures 7a to 7h, the left hand side shows the masking effect of original copy machine noise by the background noise and the right hand side is that of the modified copy machine noise. In every cases, masking effect is smaller with the modified sound. It means that modified sound is easier to mask compared with the original printer noise. By modifying the rise and fall times, namely increase the value of rise time and fall time to make the envelop pattern of the hopper sound smoother, the detectability of hopper sound decreased and due to this effect the sound becomes more pleasant than the original condition. Among the various background noises including pink noises, pink noise is most efficient and effective to mask unwanted noise to some extent by the fact that S/N ratio value expressed in dB takes less value compared with the other background noises. The impression of pink noise is more wide range noise that has equal band level in each adjacent frequency band expressed in third octave band for example.

4. CONCLUSIONS

The copy machine noise emitted from the copy machine inside, especially for flattening the toner surface. The mechanical system for this purpose is called as hopper and this portion inside the copy machine makes noise due to the mechanical contact between the driver and the follower and this phenomenon is an impulsive event and the cause of impulsive. This sound is heard as unpleasant.

According to our knowledge, impulsive sounds become softer in impression by modifying the rise and fall time by the increment of rise and fall times (2). This process was done for the hopper noise to check this procedure is effective or not.

The following are the result obtained by this study.

1. The increase of rise time for the hopper noise makes the sound better in impression, namely the sound is more pleasant compared with original. The original rise time is 8ms and the sound modified has 32ms in its rise time for the best impression only for the modification of rise time.
2. Then according to the similar procedure for the fall time, the modified sound has 92ms in its fall time for better impression in pleasantness while the rise time is kept constant at 32ms. For further increase in fall time does not lead to better impression in pleasantnesss.
3. According to this experiment, the optimum sound profile for hopper sound is to set rise and fall times as 32ms and 92ms.
4. With respect to the verification of copy machine noise improvement, masking experiments were conducted using various background noise for thinking practical usage in the practical room atmospheres. In any sound atmosphere, ability of masking under the presence of various background noises, the modified copy machine noise is easier to be masked compared with the original copy machine noise.
5. Among the various background noises, pink noise is most effective noise for expecting its capability to mask copy machine noise. This is due to the noise power in each frequency bands equally distributed from low to high frequency bands.

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