An Experimental Study on the Noise of Chain Saws

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I Foreword

Chain saws have been rapidly spread over the whole country for forestry operations, especially for felling and bucking of trees, in recent few years. It is estimated that about 25,000 one-man motor saws are used by the forest workers of Japan. According to this fact, also the problem of the noise has been arroused among the forest workers, and this problem is also seriously considered by the progressive forest managers. The authors attempted to make a first step to find out any approach to solve the problem. In this paper, the results of the experimental investigation and some significant aspects of the noise of chain saws are reported.

The basic experiment was executed in the campus of the Tokyo University and in the working yard of the Shingū Shōkō Co's factory of Tokyo in July~August 1963, while the field experiment was carried out in the National Forest in Shizuoka prefecture in November of the same year.

These experiments and analysis of the results were performed by S. Ohsato under general guidance of S. Kato. The authors would like to pay thier best acknowledgments to Mr. M. Motokado, Mr. K. Ishizaki, Mr. H. Noto, Mr. T. Kadoi and Mr. T. Yokokōji, the colaborators of the experiments.

II Scope and methods of the experiments

The problem of the noise in the conventional chain saw operation is so much complicated that it seemed to us very difficult to solve such a problem immediately by a few kinds of simple experiments. Therefore, for the first step, scope of our experiments was limitted within the reach of the acoustical investigation rather than

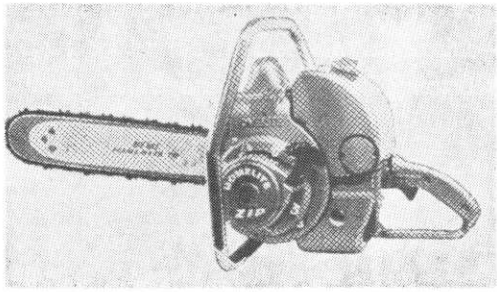

Fig. 1 HOMELITE-ZIP

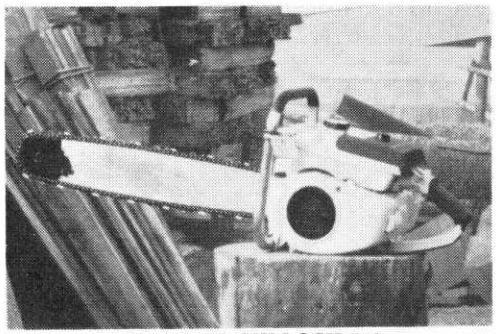

Fig. 2 McCULLOCH-740

Fig. 3 McCULLOCH-BP-1

that of the physiological or audio-medical studies.

Three models of the machines, which are generally used in this country, were selected for the objects of our experiments. The general feature and the technical data of these chain saws are shown in Fig. 2, Fig. 3 and Table 1. They are all one-man motor saws of the direct drive type with 2-cycle gasoline engine and diaphragm carburator.

Our main aim of the experiments were;

(1) To find the sound pressure level of noise at different engine speed, at different distance and different direction from the machine.

(2) To find the most distinguished range of the frequency of sound which is produced by the machine in various conditions of operation.

(3) To find the main parts of the machine which originates the most harmful noise.

(4) To find the sound pressure level and composition of noise under normal condition of practical felling and bucking operation in logging.

Therefore, the measurement of the sound pressure level, analysis of the sound frequencies and measurement of the engine speed were the most dominating work of our experiments.

Table 1 Technical data of the chain saws

Chain saw model	HOMELITE-ZIP	McCULLOCH-BP-1	McCULLOCH-740
Engine power (HP)	5	5	7
Displacement (cc)	77	44	99
Engine speed (p.r.m.)	7000	12000	9000
Fuel tank capacity (*l*)	1.56	0.95	1.50
Quantity of gasoline and oil	16:1	16:1	16:1
Bar lenth (cm)	43.2	48.3	61.0
Weight of engine (kg)	8.2	7.03	10.5

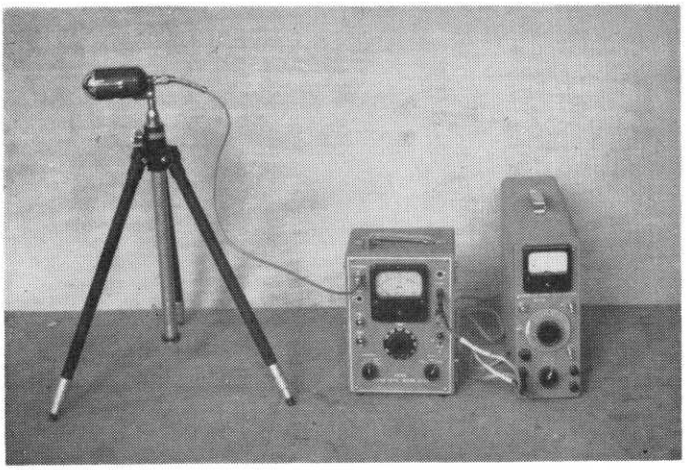

Fig. 4 Sound level meter and frequency analyzer

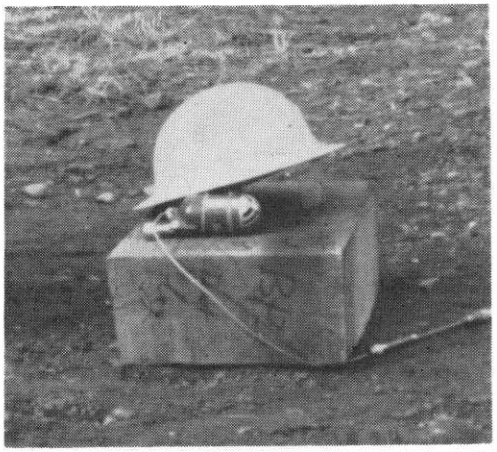

Fig. 5 The microphone attached to the operator's helmet

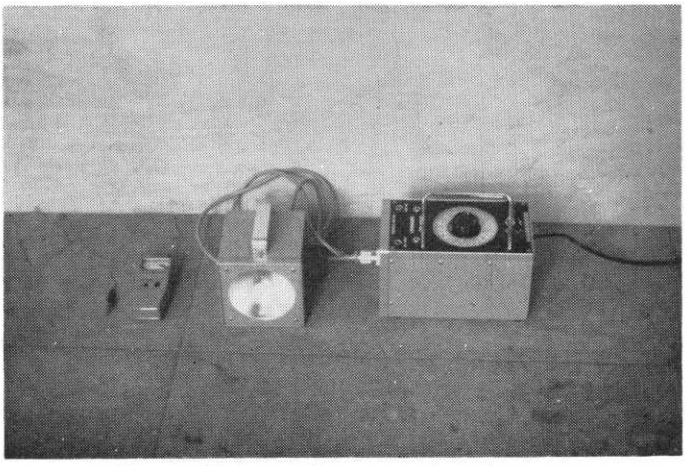

Fig. 6 Engine tachometer and stroboscope

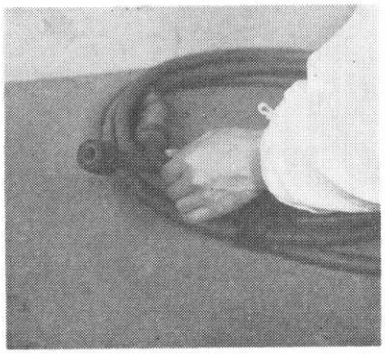

Fig. 7 The long rubber hose used for reduction of suction noise

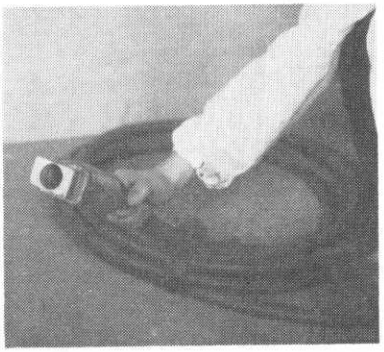

Fig. 8 The long rubber hose used for reduction of exhaust noise

For the measurement of sound pressure level, a well adjusted microphone and a sound level meter was employed, while for the analysis of the sound frequencies a frequency analyzer was connected to the sound level meter. These apparatus, shown in Fig 4, were made by Japan Electronic Instrument Co., Ltd.

For the field experiment, the same microphone was attached to the operators, helmet at the position of his ear as shown in Fig. 5.

Engine speed or r.p.m. of the sproket axel of engine, was measured by a stroboscope. For the field experiment, an ordinary electric tachometer was used instead of the storoboscope. These instruments are shown in Fig. 6.

For the purpose of eliminating inlet air suction noise and exhaust outlet noise, long rubber hoses, shown in Fig. 7 and Fig. 8, were attached to the engine.

Ⅲ Noise of a chain saw driven without any outting-load

(a) Three dimensional distribution of noise

A chain saw engine was placed on the ground instead of being held by operator's hand. In this case the bar and the chain were taken off from the machine to avoid the danger of over heating of these parts during the high speed operation of the engine. Then the engine was started and gradually speeded up to the normal high speed and kept it practically constant. The sound pressure level at various situation around the machine was measured by the sound level meter by means of the microphone, which was moved three-dimensionally from one point to another successively.

Values of sound presure level at 30 cm point in each direction were observed while the engine was driven at different speed, from law to high according to the capacity of each model. It is obvious that the directivity of distribution of the noise is more or less attributed to the design and structure of the machine.

The average values of the sound pressure level in dB measured at 30 cm of distance to each direction, e.i. front side, rear side, left hand side, and right hand side from the engine are listed on the Table 2.

From the measured values of the sound pressure level at every 10 cm points (from

Table 2 Values of sound pressure level at 30 cm points in each direction

Chain saw model / Direction	HOMELITE-ZIP	McCULLOCH-BP-1	McCULLOCH-740
Engine speed (r.p.m.)	7000	12000	9000
Front (dB)	123.8	119.3	118.0
Rear (dB)	117.5	114.7	121.0
Left (dB)	118.2	115.2	114.7
Right (dB)	116.8	117.2	124.5

Table 3 Sound pressure levels of three different chain saws used for practical felling and bucking operation

Chain saw model	HOMELITE-ZIP	McCULLOCH-PB-1	McCULLOCH-740
Felling (dB)	116.7	115.0	116.0
Bucking (dB)	112.0	115.0	116.5

(Noise at the operator's ear, engine speed maximum)

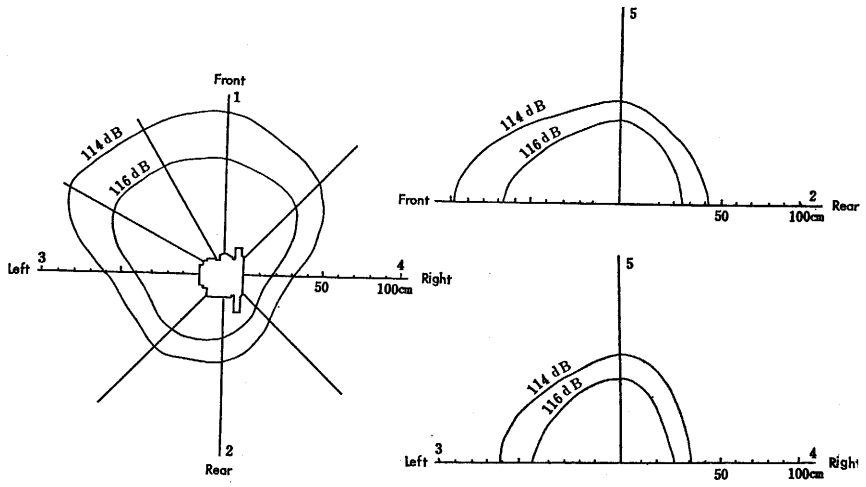

Fig. 9 The directivity of HOMELITE-ZIP chain saw engine noise with muffler, engine speed at 6600 r.p.m.

30 cm to 100 cm.) in each three dimentional direction, points of equal pressure level are plotted to obtain contour lines. For example, contour lines in this sence for the HOMELITE-ZIP, engine speed at 6600 r.p.m., are shown in Fig. 9. To understand the meaning of this figure, attention should be payed to the fact that the position of the muffler of this machine is on the front side and rear side is closed. Fig. 10 is a noise spectrum made by the results of this experiment.

(b) Relation between engine speed and noise

Engine speed and corresponding sound pressure level were measured simultaneously in the same method mensioned above. The results are shown in Fig. 11, Fig. 12 and Fig. 13. We could recognise the tendency, that sound pressure level increases when

engine speed is higher. But the sound pressure level is not always strictly proportional to the engine speed. This facts may be attributed to the designe of each machine. As a whole, maximum values of the sound pressure level are considerably high. They are more than 110 dB and much undesirable.

(c) Composition of noise analysed by the frequency analyzer.

Relating to the noise measurement at 30 cm points mentioned above, the composition

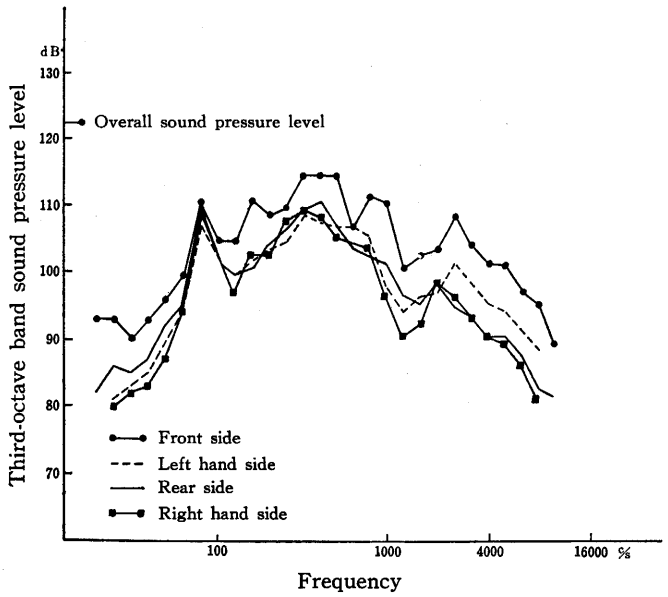

Fig. 10 Noise spectrums of HOMELITE-ZIP chain saw engine with muffler, engine speed at 6600 r.p.m.

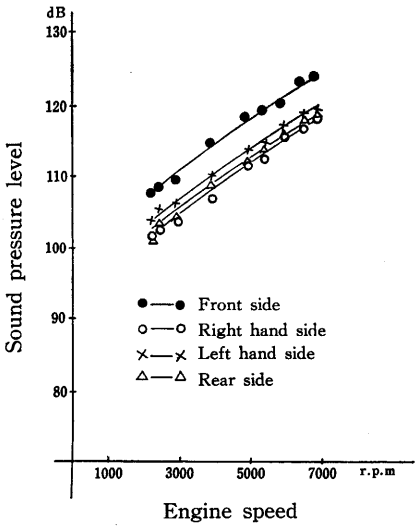

Fig. 11 Sound pressure levels of HOMELITE-ZIP chain saw engine at various engine speed

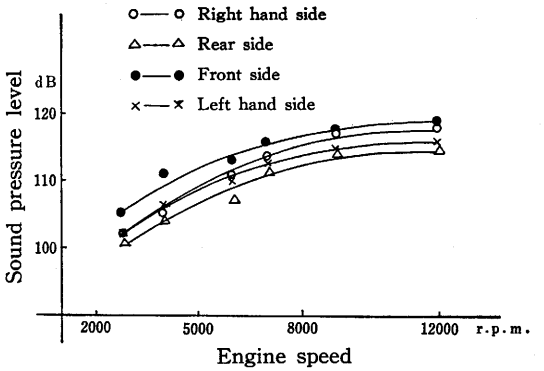

Fig. 12 Sound pressure levels of McCULLOCH-BP-1 chain saw engine at various engine speed.

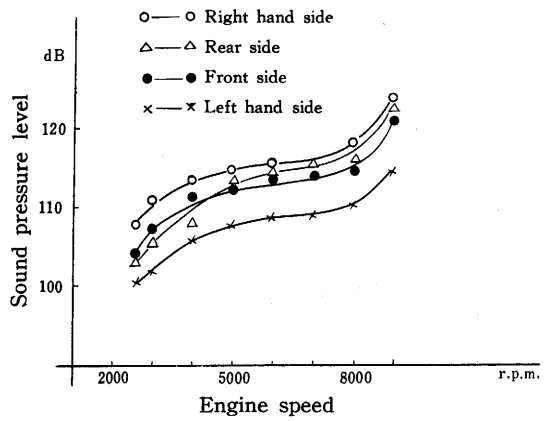

Fig. 13 Sound pressure levels of McCULLOCH-740 chain saw engine at various engine speed

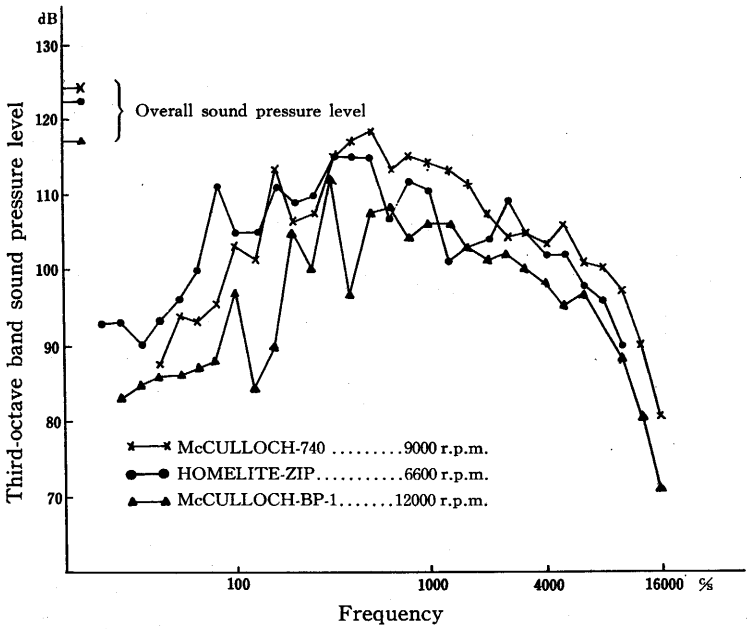

Fig. 14 Noise spectrums of three chain saw engine models. Noise, at 30 cm apart from the muffler of the chain saw.

of the noise was analysed at the same time by means of the frequency analyser. The accuracy of the measurement of this instruments is 1/3-octave band unit. One can overlook results of this experiment by the noise spectrum shown in Fig. 14. As a whole, the noise spectrum of chain saws covers almost all range of the ordio-frequency, much concentrated over the dialog range and also shows higher level at 4,000 cycle range, which is said to have a close relation to the hearing loss of the operator from the ordiomedical point of view.

IV Effect of muffler

To check the effect of muffler, which is attatched to the exhaust pipe of the engine, this muffler was taken off, and then noise at 30 cm point was measured and analysed. HOMELITE-ZIP was employed in this experiment.

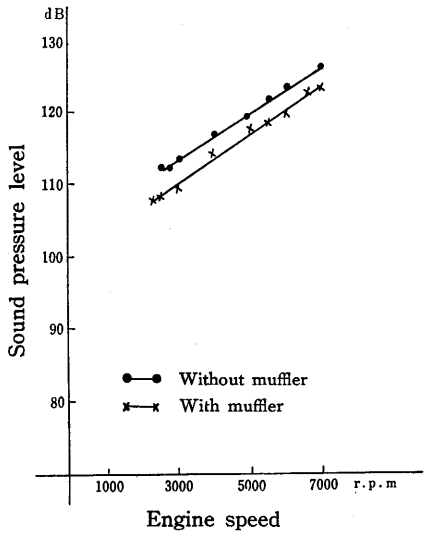

Fig. 15 Effect of muffler, e.i. noise compared at 30 cm apart from the front side of the chain saw engine.

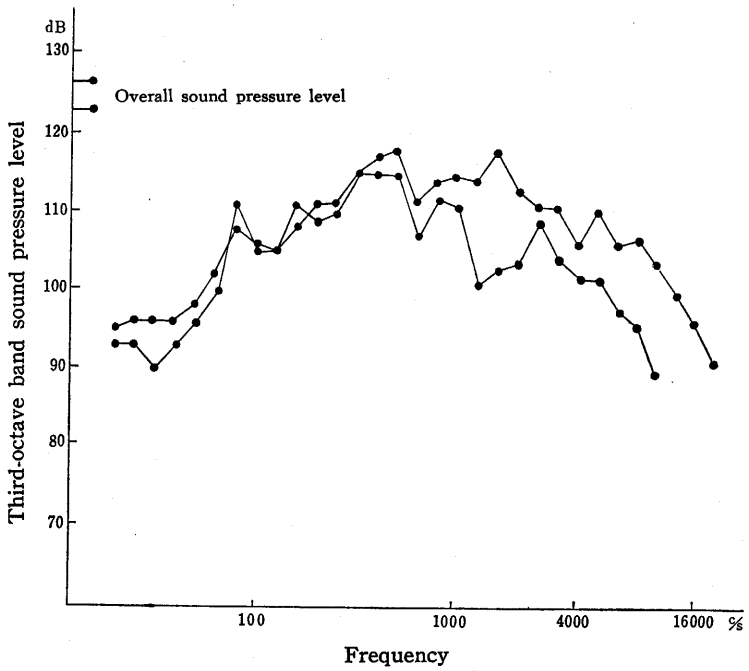

Fig. 16 Difference of noise spectrum between the chain saw engine without muffler and with muffler; noise spectrum, at 30 cm apart from the front side of the chain saw engine, engine speed, at 6600 r.p.m.

The values of sound pressure level and noise spectrum of a chain saw differs considerablly from those of a chain saw without muffler. The differences, shown in Fig. 15 and Fig. 16, were considered to be the influence of the muffler. It is obvious by these figures that the muffler is effective to reduce the sound pressure, and especially effective to reduce the higher frequency noise. But the absolute effect, is very small so that it could not be overestimated.

V **Effects of gas explosion, chain and air friction.**

(a) Gas explosion

Noise of a chain saw may be a mixture of the noise due to gas explosion and the noise produced by the moving parts of the machine and air friction. To check the effect of gas explosion, so called "motoring test" was carried out. A pully was attatched to the sproket axle of a chain saw. An electric motor (5 HP) was transmitted to this pully by means of a V-belt and the engine was driven by the electric motor without any gas explosion. HOMELITE-ZIP was used for this motoring test, and the noise was measured and analysed in the same way as mentioned above. The result is shown in Fig 17 and Fig 18. The difference, about 20 dB between the normal gas driven engine and the electrically driven engine is considered to be the effect of gas explosion, and it is obvious in the figure that the mechanical noise of the machen is considerably strong when the machine is driven in high speed.

(b) Chain

The saw chain was attatched to the machine, and the same "motoring test" was performed. The result of this experiment is shown in Fig. 18. The effect of moving saw chain is more evident when the chain is running high speed and it increases the noise of higher frequency up to 5,000 c/s range.

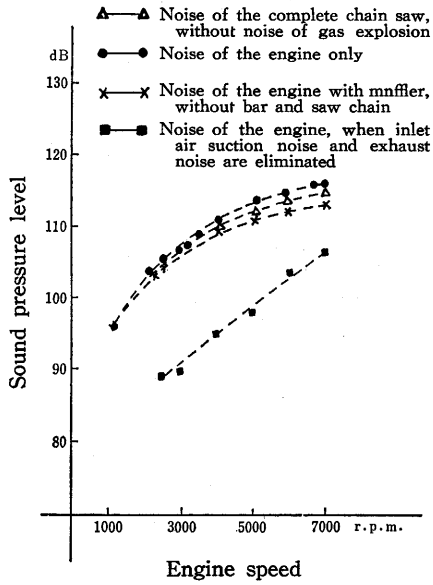

Fig. 17 Results of motering tests–(1) Sound pressure levels by HOMELITE-ZIP chain saw, by which certain parts of the machine are taken off, at various engine speed.

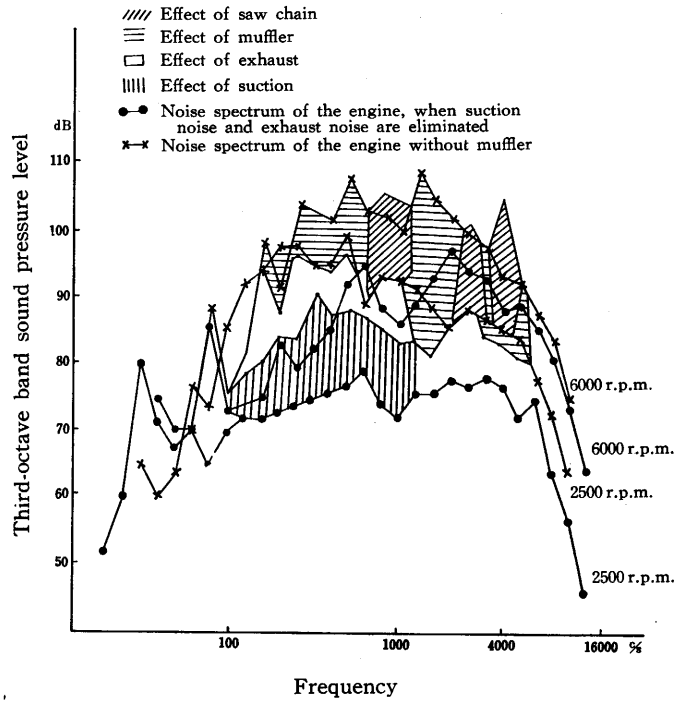

Fig. 18 Results of motoring tests-(2) Noise spectrums of HOMELITE-ZIP chain saw, by which certain perts of the machine are taken off, at various engine speed.

(c) Air friction

The noise produced by air friction at inlet (suction) and outlet (exhaust) was also examined. To eliminate the noise due to the air friction, long rubber hoses were attatched to the both openings. And the same motoring test was performed. Effects of the air friction is shown in Fig. 17 and Fig 18. It is recognised from these figures that the effect of the air friction in regard to the sound pressure is considerably large. As to the nature of noise, the suction noise is of lower frequency sound. while the exhaust noise is of higher frequency sound.

VI **Noise of a chain saw in practical logging operation.**

Noise in practical felling and bucking operation with three models of chain saws, McCULLOCH-BP-1, McCULLOCH-740 and HOMELITE-ZIP, was measured at the logging site. In this case, noise produced by the cutting chain, which is chipping wood material was more or less added to the noise of machine. By means of setting a microphone at the rime of the operator's helmet, about 50 cm apart from the engine, the sound pressure level was measured, and frequencies were analysed.

The results are shown in Table 3, Fig. 19, and Fig. 20. The overall sound pressure level was between 110 dB and 120 dB. The sound pressure level at 4000 c/s was aboat 90 dB and up.

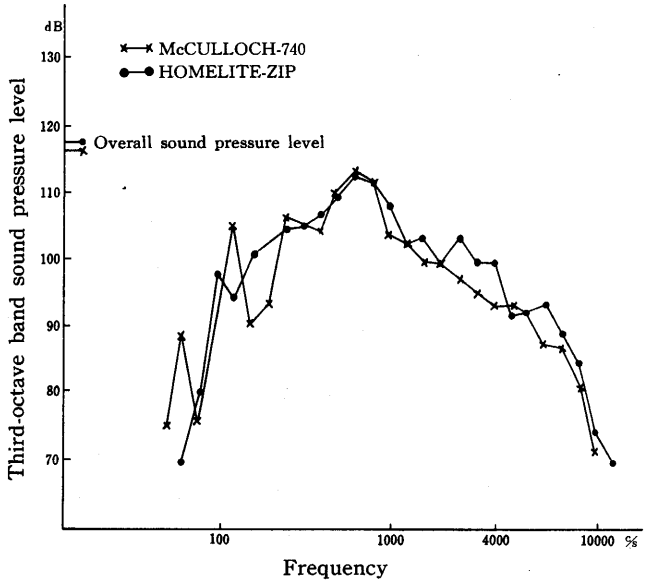

Fig. 19 Noise spectrums of two different models of chain saws in felling operation.

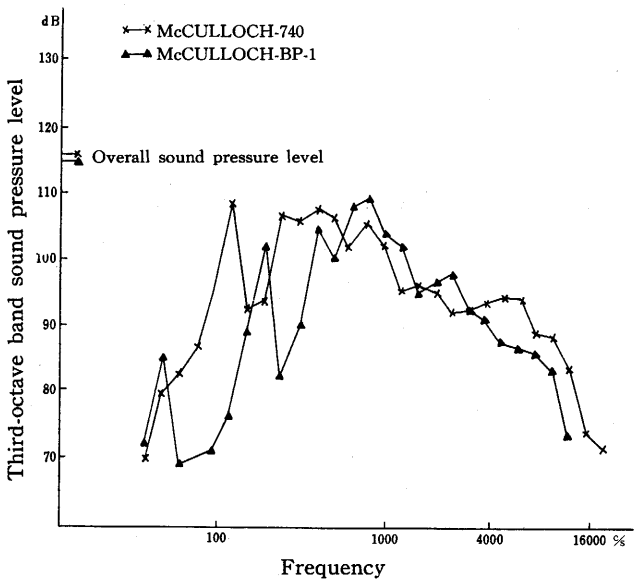

Fig. 20 Noise spectrums of two different models of chain saws in bucking operation.

VII Summary

(1) The sound pressure level of the noise produced by the three models of the chain saws used in this experiment is more than 110 dB at the position of the operator's ears.

(2) The noise of the chain saw engine is in high level over a broad band of frequencies.

(3) Sound pressure levels of 1/3 octave band transfer from lower frequencies to higher frequencies according to the increase of engine speed.

(4) The chain saw noise has a certain directivity attributed to the designe and structure of the machine.

. (5) Sound level of the mechanical noise produced by the machine is considerably high, when it is compared with the noise produced by gas explosion.

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チェンソーの騒音に関する実験的研究

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摘　　要

林業におけるチェンソーの普及は，ここ数年間に劃期的な普及を示し，その数は約25000台にも及んでいる。それに伴い騒音の問題が俄かに進歩的な経営者や作業員の間で重視されるようになってきた。

本実験は，その最初の手懸を得るため，わが国で一般に用いられている HOMELITE-ZIP, McCULLOCH-BP-1, McCULLOCH-740 の3機種について各種の測定を行なった。

測定は大別すると，チェンソー駆動時の騒音とモータリングにおける騒音に分けられ，そのおのおのの場合について「エンジンの回転数と騒音の大きさとの関係」及び「チェンソーの使用方向と騒音の大きさとの関係」について，騒音計と周波数分析器を用いて測定した。その結果，チェンソーの騒音の大きさは作業員の耳の位置で 110 dB を越えていること，また，騒音スペクトルを見ると，エンジンの騒音の周波数の範囲は殆ど可聴帯 (20～20,000 c/s) の全域にわたっていること，モータリングの結果からは，機械音は回転数を上げるにしたがって周波数の大きい部分 (例 32→4,000 c/s) に主力音があらわれてくること等がわかった。また，チェンレーの騒音は指向性を有し，使用方向によって異なった値を示した。以上のことから早急に騒音防止，及び，難聴防止の対策をたてることが必要があると思われた。