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TECHNICAL PREVENTIVE MEASURES IN JAPAN

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ABSTRACT

Technical preventive measures against vibration syndrome in the field of industrial health are reviewed in the present paper. The first technical prevention measure is to reduce vibration transmission from the tools to the operators. This measure employs vibration isolators between the handles and vibration sources of machine tools. Handles of tools using Neidhalt dampers, shear type rubber mounts and springs have reduced frequency-weighted acceleration levels ($L_{h,w}$) from 2 dB to 10 dB ($L_{h,w}$ (dB)=20 log a/a_o; a: frequency-weighted acceleration (rms), $a_o = 10^{-5}$ m/s^2) in Z direction, while no reduction was found in X, Y directions. The second measure is to reduce vibration at the source; New chain saws have been developed to reduce vibration with twin cylinder instead of a single cylinder engines. This cancels unbalanced movements inside the internal combustion engine. Such chain saws reduced $L_{h,w}$ values more than 10 dB in both front and rear handles except in Z direction of the front handle. A new type of impact wrench has been devised with an oil pulse device to avoid direct metal contact inside the power source. This new impact wrench lowered $L_{h,w}$ values more than 10 dB in three directions. The third measure is to use a remote control system or to substitute another machine generating less vibration. Vibration reduction at the handle lever of the remote control chain saw was more than 20 dB. A more effective means is to substitute other machines for conventional tools: a hydraulic wheel jumbo instead of a leg-type rock drill; a hydraulic breaker instead of a hand-held breaker. However, these heavy machines produce whole-body vibration which might give rise to other problems such as back pain.

Key Words: Technical improvement, Preventive measure, Vibration, Hand-held tool

INTRODUCTION

Since the 1960s in Japan, vibration syndrome has been found among forest workers using chain saws. The prevalence[1] of VWF (vibration-induced white finger) among forest workers increased from 30% in the late 1960s to 60% in the early 1970s. At that time, vibration syndrome was indentified as a social problem by researchers, principally medical doctors. Guidlines[2] for working with chain saws were released by the Labour Ministry of Japan in 1970. The most important item concerned the number of working hours, that is, no more than two hours a day. In addition, chain saw use should alternate with jobs not requiring chain saws. It has also required regular maintenance of chain saws and periodic medical examinations. In 1975, a guidline[3] for hand-held tools other than chain saws were issued by the Ministry. These were very similar to the chain saw guidlines. In 1977 the Ministry established a structural standard[4] for chain saws, which required an acceleration value (non frequency-weighted) below 3 G (29.4 m/s^2). Since these regulations in the late 1970s, general preventive measures and technical improvements have been developed. General preventive measures[5,6] include selection of hand-held tools with the least vibration, improvement of the tools, limitations on operating time for the workers, improvement of working methods, retaining warmth of the body in the working environment, the use of vibration-protection gloves, periodic health examinations and health edu-

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cation. This paper reports on one of these preventive measures, that is, technical improvement of the machine tools used in Japan. The first improvement[1] was the design of an anti-vibration handle in the 1960s. Although vibration acceleration levels decreased to some extent, there was a limit to the improvement offered by the handle. As a second measure,[1] a remote controlled chain saw was introduced in the 1970s which decreased vibration almost completely. Finally,[1] a newly designed chain saw engine was developed between the late 1970s and the mid-1980s which achieved excellent results. This paper reviews some examples of improved tools, their mechanism and their effects.

TECHNICAL MEASURES

In order to take technical preventive measures, vibration data must first be obtained and reported. These preventive measures are classified into three groups: reduction of vibration transmission to operators; reduction of vibration at the source; and substitution of another machine.

Reduction of vibration transmission includes such improvements as inserting vibration isolators between the handles of machine tools and vibration sources. Fig. 1 shows an isolator called a Neidhalt damper which is composed of two metal holders and rubbers. One of the holders is connected to a handle grip and another to the vibration source. Vibration from the source is then absorbed to some extent by the rubbers. Some examples of the use of Neidhalt dampers are shown in Fig. 2(a)(b)(b'). This damper is applied to the handle[7] of a rock drill (leg-type) in Fig. 2(a). Reduction of vibration was 5 dB in Z direction. It reduced about 44% of vibration amplitude. However, no vibration reductions were found in X and Y directions. Another example is an electric hammer drill[8] which has two Neidhalt dampers, one for each side handles. Shear type rubbers are also used in this case, as shown in Fig. 2(b)(b'). Reduction of vibration was 7 dB (about 55%) in Z direction. No vibration reductions were found in X and Y directions. Shear type rubber[8] was also used in the handle of another type of electric hammer drill (Fig. 3(a)(b)). Results of this vibration reduction were 2 dB (about 20%) in Y and Z directions, while the protection handle amplified the vibration value, $L_{h,w}$ in X direction. A tie-tamper[9] is used on railways to tamp ballast under the rails. Fig. 4 shows a tie-tamper with a conventional handle and with a protection handle. The conventional type has two curved leaf springs. The protection handle has a different type of spring. This protection handle reduced vibration more than 10 dB (about 70%) in directions X, Y and Z.

Reduction of vibration at the source is achieved by design improvements in the tool parts from which vibration originates. Fig. 5 shows a new type of impact wrench[10] with an oil pulse device to avoid direct metal contact. This new impact wrench is a combination of a standard air motor and a unique hydraulic pulse unit. The high speed rotation of the air motor increases the oil pressure in the front pulse unit to deliver a series of hydraulic pulses to the anvil to facilitate fastening and loosening of nuts or bolts. As shown in Fig. 5, two seal points are aligned concentrically, and two other seal points are made eccentric by some degree from the center line in order not to make the sealing status in 180 degree rotation. At stage (II), A-A (concentric) contacts C-C, but B-B does not contact D-D. In this stage, when the anvil is free of load, it firmly contacts the inner surface of the liner under pressure from the spring- loaded driving blade, and rotates together with the liner block (liner, liner casing, front and rear liner plate) powered by a conventional air motor. At stage (IV), A-A contacts C-C and B-B contacts D-D. In this stage, the anvil, when loaded, is forced to stall, but the liner block continues to rotate compressing oil in one of the separated compartments. The oil flow through the compartments is suddenly cut which raises oil pressure on the compressed side instantaneously. This hydraulic pulse energy works on the driving blade to deliver torque to the anvil. Reduction in the vibration of the oil pulse wrench was more than 10 dB — 16 dB (70 — 85%) in X, Y and Z directions.

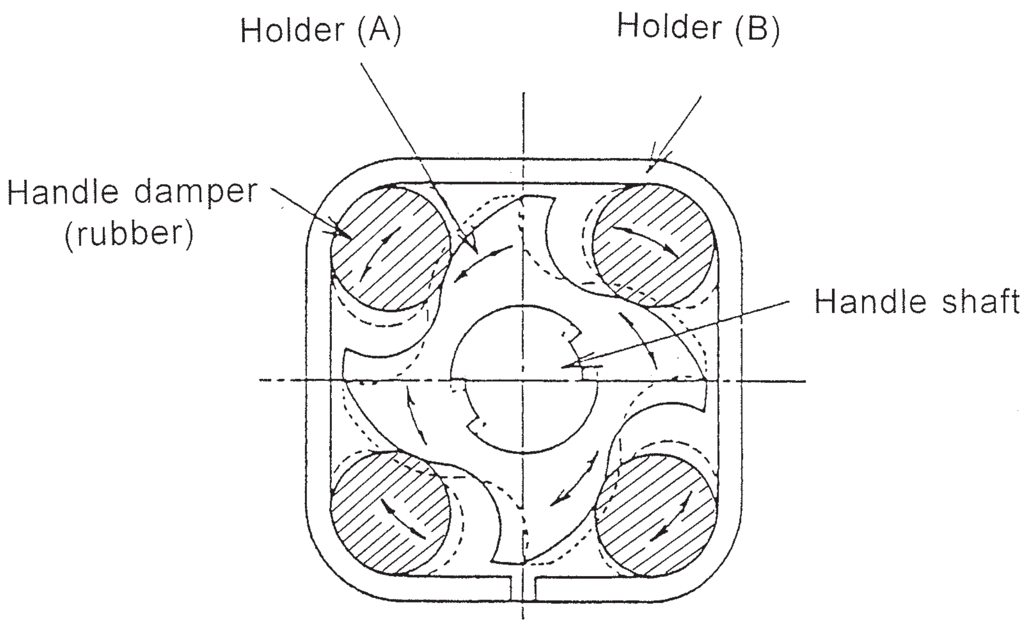
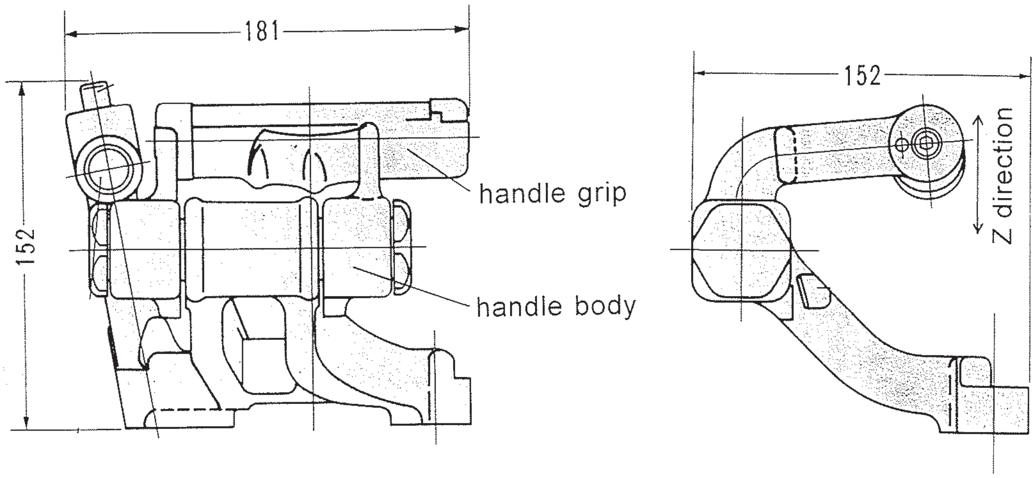


Fig. 1. A unit of Neidhalt damper with rubbers between holders.



	$L_{h,w}$, Z
Conventional handle	124 dB
Protection handle	119 dB

Fig. 2(a). An example of an anti-vibration handle using Neidhalt dampers (leg-type rock drill).

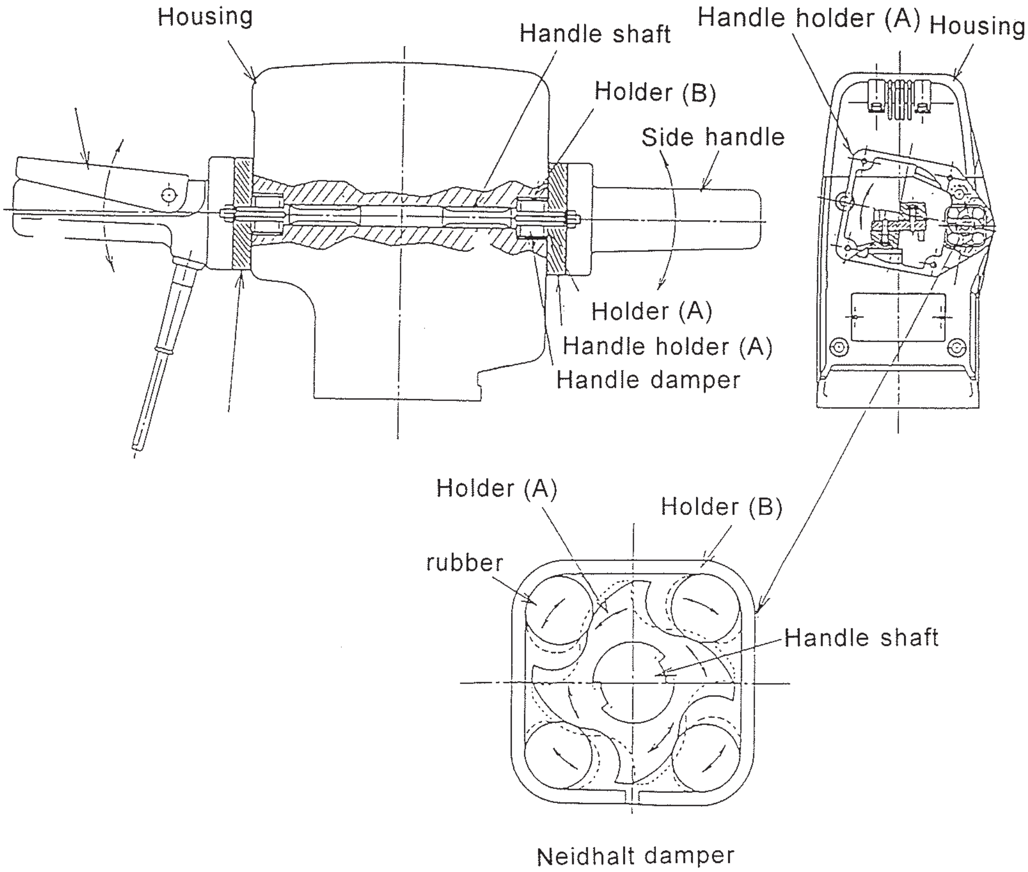
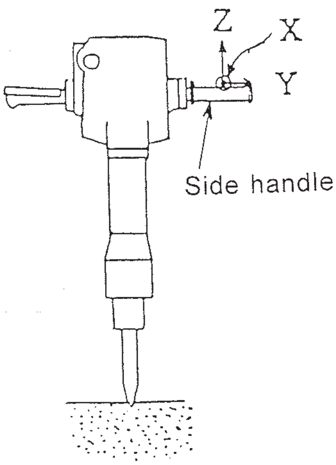


Fig. 2(b). An electric hammer with anti-vibration handles using Neidhalt dampers.



Direction	$L_{h,w}$ (dB) X	Y	Z
Conventional handle	109	107	123
Protection handle	108	107	116

Fig. 2(b'). Vertical view of electric hammer with frequency- weighted acceleration levels ($L_{h,w}$).

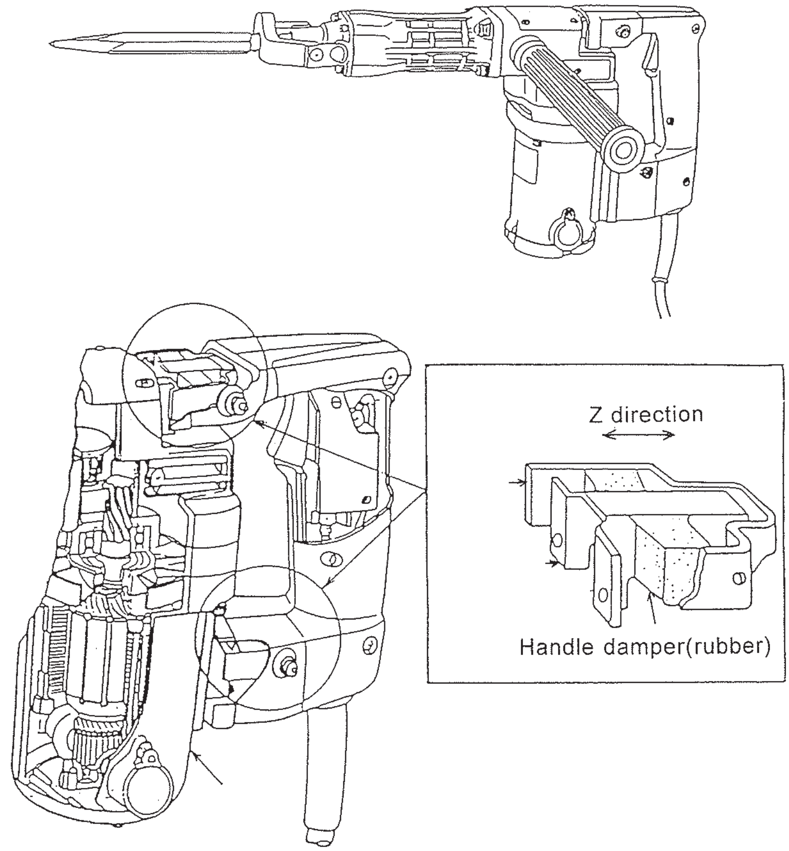
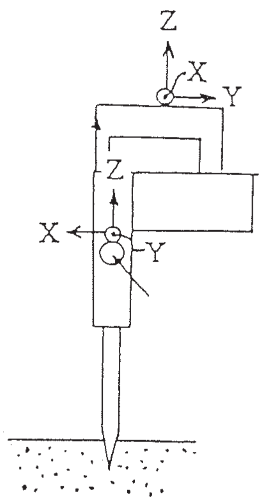
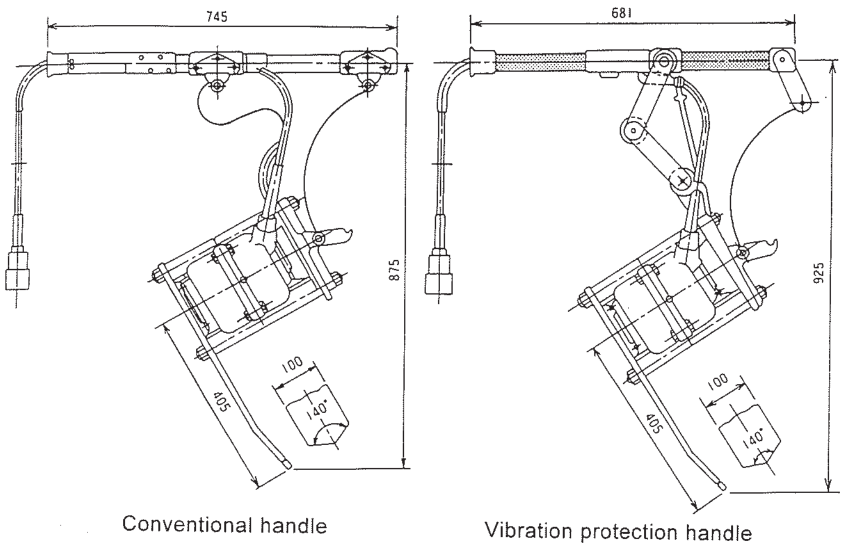


Fig. 3(a). Another electric hammer with anti-vibration handle using the shear type of rubbers.



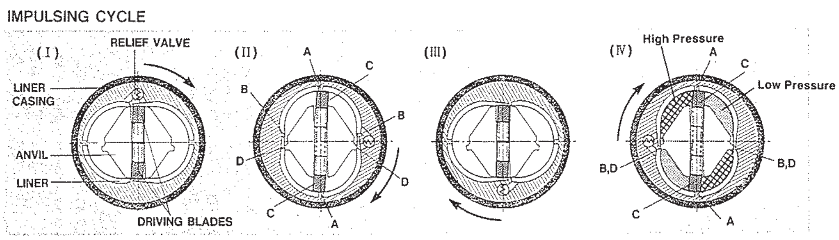
Right handle Direction	$L_{h,w}$ (dB) X	Y	Z
Conventional handle	117	119	121
Protection handle	118	117	119

Fig. 3(b). Vertical view of electric hammer with the shear type rubbers and $L_{h,w}$ values.



Direction	$L_{h,w}$ (dB) X	Y	Z
Conventional handle	119	122	121
Protection handle	107	110	111

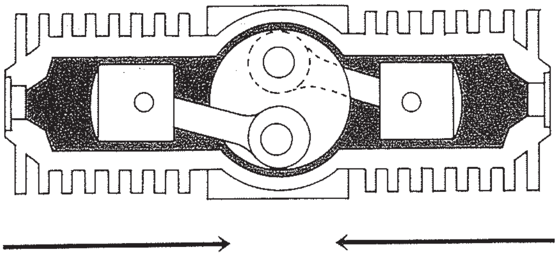
Fig. 4. Tie tamper with anti-vibration handle using metal springs.

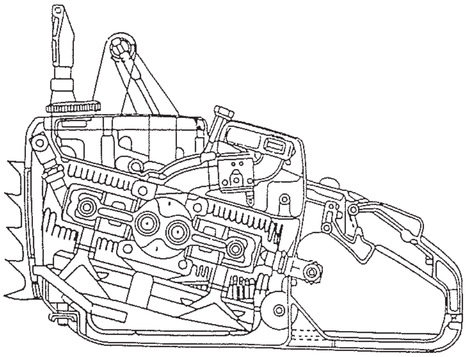


Direction	X	Y	Z
Impact wrench	109	113	111
Oil-pulsetool	99	99	95

Fig. 5. Impulsing cycle of impact wrench with oil pulse device.

Parts acting as a vibration source in chain saw[11] have also been newly designed, using a twin cylinder instead of a single cylinder engine (Fig. 6). This twin-cylinder engine is arranged oppositely, and simultaneous firing allows complete balance between the reciprocal motions of the two pistons. Rubber isolators fixing on the connecting parts of the chain saw and rubber grips on both handles absorb the vibration. In addition to these vibration protection measures, handle





Direction	$L_{h,w}$ (dB) X	Y	Z
Conventional chain saw	78	86	88
Twin chain saw	77	72	67

Fig. 6. New type of chain saw with twin-cylinder engines.

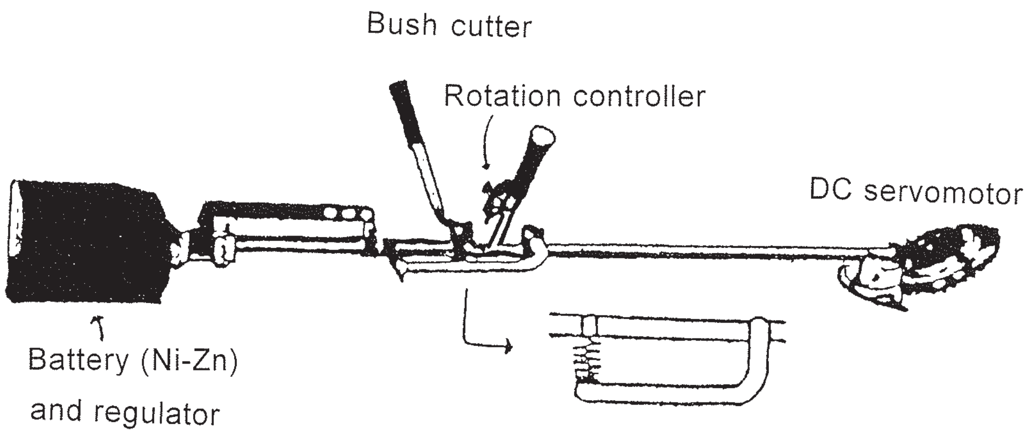


Fig. 7. Bush cutter driven by an electric battery.

heaters are installed in some chain saw to warm the hands of the operators. Reduction in the vibration of the new type of chain saw was about 20 dB (90%) in Y and Z directions of the rear handle. Although reduction of vibration in X direction was insufficient, the vibration level of conventional chain saws was already judged to have reached satisfactorily low levels. Front handles have nearly the same characteristics.

A new bush cutter[12] was devised, driven by an electric battery and DC servo motor instead of an internal combustion engine (Fig. 7). Although the weight of this system increased by about 2 kg over that of a conventional bush cutter, vibration was reduced 15 dB (about 80%).

Table 1. Temporary Threshold Shift (TTS) Between Before and After Using Chain Saws and Bush Cutters

Kind of Tool	Source of Energy	Non-weighted Vib. Acce. Levels (dB)	TTS at Top Handle (dB)	TTS at Rear Handle (dB)
Chain saw-A	Single cylinder	148	10.0±1.8	10.0±1.8
Chain saw with warm grip-AW	Single cylinder	148	0.6±2.1	3.8±4.7
Chain saw-A	Single cylinder	148	12.4±1.0	14.2±1.8
Chain saw-b	Twin cylinder	135	9.2±0.8	8.7±0.8
Chain saw-C	Single cylinder	144	10.4±1.0	9.6±0.7
Chain saw-b	Twin cylinder	135	5.0±0.3	5.0±0.6
Bush cutter-A	Single cylinder	142	4.8±0.5	5.5±1.1
Bush cutter-B	Electric battery	129	0.1±0.5	0.9±0.6

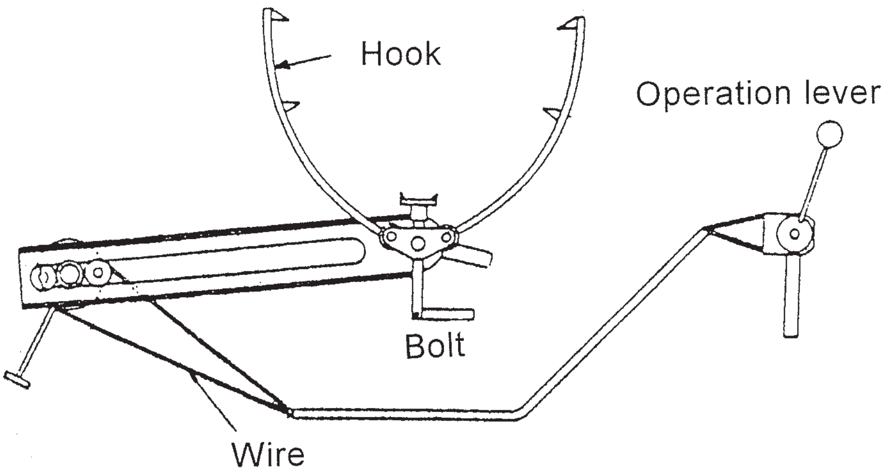


Fig. 8(a). Plane view of remote control chain saw.

From the viewpoint of human response, Yamada and Sakakibara[1] examined TTS (temporary threshold shift) as an effective physiological index for improved tools. TTS is the change in vibratory sensation before and after using a chain saw or bush cutter. The larger the TTS is, the more harmful are the effects on the human body. Table 1[1] shows a comparison in TTSs between new and conventional tools. Vibration tools in this Table were not identical with the tools described above in the reduction of frequency-weighted acceleration levels. Compared to chain saws with a single cylinder, TTSs of chain saws with twin cylinder were smaller by about 3 dB to 5 dB in the front handle and 5 dB to 7 dB in the rear handle. In chain saws with a warm grip (single cylinder), TTS was smaller by about 9 dB in the front handle and 6 dB in rear handle. In the case of bush cutters, TTSs were smaller by about 5 dB in both handles.

We now consider the use of a remote control system or substitution of another machine. A remote control chain saw[13] was devised. It was composed of a support system (5 kg) in Fig. 8(a) (plane view) and Fig. 8(b) (vertical view) and a conventional chain saw which is set to this support system. The support system is fixed to a tree with a hook. It has a control lever to change

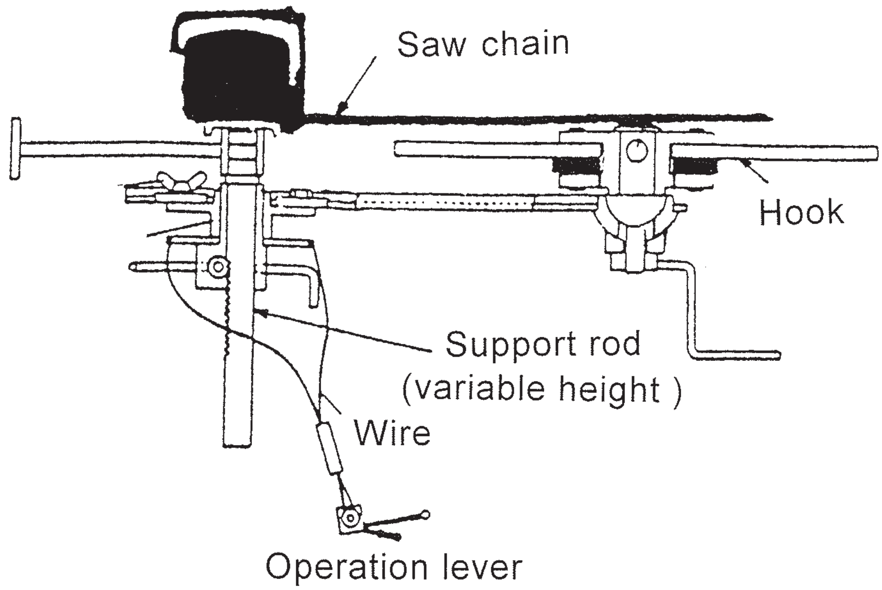


Fig. 8(b). Vertical view of remote control chain saw.

the engine speed with no need for the operator to support the chain saw itself. Using this system, vibration reduction at the handle lever was more than 20 dB. But it takes about twice as long to set up the system than to start a conventional chain saw in the field, because the lever is connected to the main body of the chain saw through a wire which is capable of isolating the vibration.

A more effective technical measure of vibration protection is to use another machine as a substitute for a conventional tool. For example, a hydraulic wheel jumbo instead of the leg-type rock drill, or a hydraulic breaking machine instead of a hand-held breaker or other hand-held tools. However, these heavy machines will produce whole-body vibration which might have other harmful effects such as back pain.

DISCUSSION

Technical measures against vibration in hand-held tools have been developed since the 1970s following advice by researchers and notification by the Labour Ministry which has regulated vibration acceleration values and daily working hours in Japan. The present paper reviewed examples of improvements such as anti-vibration handles and tools redesigned to reduce vibration at the source. There was a limited decrease in vibration acceleration values due to anti-vibration handles. Redesigning to reduce vibration at the source produced more marked decreases. There is a need for further fundamental improvements to reduce vibration acceleration such as the new type of chain saw and impact wrench which have a different type of mechanism in the power source. This, however, takes considerable time and investment. In addition to the improvements described above, tools should be designed according to good ergonomic practice, since the designs of conventional hand-held tools have a record of causing problems such as VWF and musculo-skeletal injuries.[14)]

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