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Use of a Digital Waveform Analyzer, Accelerometers, and a Load Cell to Measure Momentum and Clamping Forces of Killing Traps for Furbearers

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ABSTRACT: This paper describes a procedure that can be used to mechanically evaluate the momentum and clamping forces of a killing-type animal trap. The instrumentation, set-up procedures, and software packages used to analyze the data are described. Some typical results of the firing of a trap and the graph generated by the software are shown.

KEY WORDS: killing traps, momentum, clamping force, waveform analyzer, accelerometers, load cell

Accelerometers have been used for a wide range of applications, from vibration analysis of rocket boosters to shock measurements in vehicular testing. Likewise, uses of load cells range from determining the weight of various objects to force measurements in punch presses. However, a little known application of both these measuring devices is the mechanical evaluation of animal killing type trapping devices.

The momentum and clamping force of the trap are measured to evaluate the mechanical potential of a trap to effectively kill an animal. The momentum is a measure of the impact that a striking bar can deliver to an object. Momentum is the product of the velocity of a striking bar times its equivalent mass. The clamping force is the steady-state force exerted on an animal by the jaws of the trap after the striking force has been delivered.

In the past, it was first necessary to weld a stud to the striking bar and then mount the accelerometer in place to determine the momentum of the trap. Although the brand of equipment varied depending on when and where the testing was being performed, the general procedure remained constant [*1-3*]. The accelerometer signal was passed through a signal conditioner to a chart recorder, then through a digitizer to a second permanent tape storage unit. The signal was then integrated to give the velocity and, again, to give the displacement of the trap. It was reported that the limiting frequency response of the equipment was 3600 Hz for the tape recorder [*1*]. This testing system contained many pieces of equipment through which the signal had to be fed, and many transfers of data where contaminated record or playback heads or externally generated noise could affect the signal.

The clamping force of the jaws was determined by closing the trap by hand on a load cell that was shimmed with pieces of metal to obtain the desired final jaw opening [*1*]. The trap was then shaken to simulate the actions of a trapped animal, causing the springs to tighten. This procedure limited the minimum opening to the actual size of the load cell.

The purpose of this paper is to describe a system using a digital waveform analyzer and accelerometers that allows the sampling of information at a high frequency response with only one transfer of the data recorded from the signal conditioner. Also outlined is a method for determining the clamping force of a trap at an infinite number of openings.

Experimental Procedure

The angular acceleration of the trap was determined by spot welding an accelerometer mount on each striking jaw of the trap. The acceleration was then integrated to yield the velocity which was multiplied by the striking bar's equivalent mass to give the angular momentum of the trap. The trap was secured in place so that it had no linear motion, thus eliminating any linear momentum.

To prevent excess shock from being transmitted to the accelerometer, and to provide a standard striking object, the trap was fired on a rubber hose with an outside diameter of 27 mm (1$^3/_8$ in.) and an inside diameter of 20 mm ($^5/_8$ in.). An average momentum was calculated after ten firings. The momentum evaluation required the use of four components:

1. PCB A04 accelerometers (Intertechnology, Calgary) with a sensitivity in the 1 mV/g range. The acceleration range of the accelerometers was 5000 *g* with a maximum input of 10 000 *g*. These units generated high-level, low-impedance analog output signals which were proportional to the measurand. These units were factory calibrated with no further calibration required.
2. PCB models 480A10 and 480B power supplies (Intertechnology, Calgary) provided a constant current excitation to the accelerometer and transferred the accelerometer signal to the D6000 digital waveform analyzer (see 3).
3. The data acquisition storage and display unit used was a Data Precision D6000 Waveform Analyzer (Interfax, Montreal). The unit was equipped with a Data Precision Model 611, four channel, 100 kHz plug-in digitizer, with a frequency band width of 30 kHz. One channel was used for each accelerometer. During a

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firing, the unit was triggered by the input signal and the sweep recorded at a predetermined time base setting on the analyzer. During a sweep, each channel was sampled 512 times with the data points stored in the unit's memory. The captured signal was then processed through a program in the analyzer memory that multiplied the signal by the accelerometer constant, integrated it, and produced the velocity and displacement waveforms. Any combination of up to four waveforms could then be displayed on the CRT screen and, with the use of the cursors, the velocity could be determined at any displacement.

4. The data storage unit was a Data Precision Model 681, dual 5¼ in. floppy drive (Interfax, Montreal), which allowed the transfer of data from the waveform analyzer to an IBM PC compatible format.

A block diagram of the experimental setup is presented in Fig. 1.

Software Packages

All software was run on an IBM-PC-XT with the major storage media being a 20 MB internal hard disk, and two 5¼ in. floppy drives. The output options were a graphic terminal, graphic printer, and digital plotter. The software programs consisted of a translation package D6000 and ASYSTANT.

D6000 Program

This program was supplied by the distributer of the waveform analyzer and was modified in-house to perform specific functions. The program runs in BASICA and translates the binary data produced by the waveform analyzer to ASCII format.

At the beginning of the program, the operator is asked to input the location of the binary files and the number of files to be translated. The operator is then instructed to input the name of the binary files and the corresponding file name in which the ASCII data are stored. While the files are processed by the computer, the operator can perform other tasks.

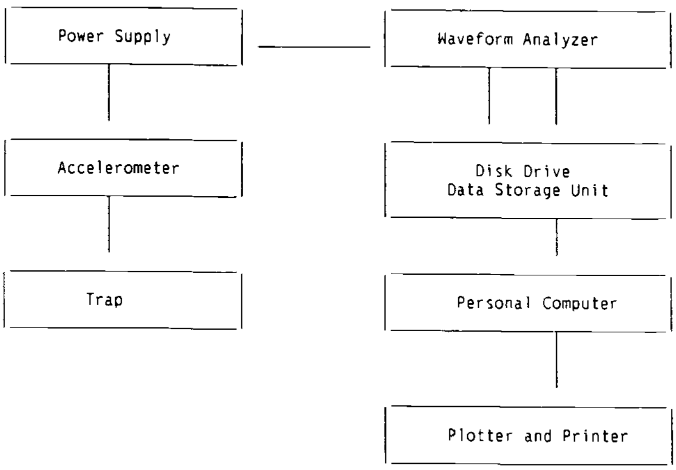

FIG. 1—*Block diagram of experimental setup.*

Asystant Program

This commercially available data analysis graphics program (MacMillan Software Company, Toronto) can generate an "average firing result" from all the acceleration waveforms. This average result can then be integrated to obtain the velocity and displacement waveforms. The momentum waveform is generated by multiplying the velocity by the equivalent mass of the trap. The displacement can be altered at will to show the trap opening.

The momentum and displacement waveforms can be cropped to eliminate any excessive pre- and post-firing information that is not necessary. These two waveforms can be plotted against each other to yield a momentum versus displacement graph which can then be output to the digital plotter (HP 7475A).

Clamping Force

The static clamping force of the trap was determined by securing the lower jaw of the trap and holding the upper jaw open with a hook connected to a load cell at any desired opening. This was accomplished by connecting one end of the load cell to a hook, and the other end to a threaded rod which passed through a square metal tube that acted as a stationary platform. A nut was then placed on the threaded rod above the square tube. Rotating the nut adjusted the height of the load cell and thus the jaw opening. The reading was recorded and then the springs shaken to simulate an animal in the trap and the new reading recorded. This test was performed before and after the trap momentum tests and required two main components: (1) a Transducers Inc. Model 182 miniature load cell (Intertechnology, Calgary), which had a 2.2 kN (500 lb) maximum capacity with a column-type sensing element; and (2) a bench model ACROTECH Model DTR-304 Digital Transducer Readout (Intertechnology, Calgary) powered by four rechargeable NiCd batteries and equipped with a low battery flag to indicate when the battery power drops below usable limits. The unit also contained a ratiometric analog-to-digital converter which compensated for battery voltage changes. The calibration of the load cell and readout was performed by suspending known weights from the load cell and recording the readout.

Setup of Test Apparatus

A trap was secured in a platform to restrict its motion to that of the closing jaws. The clamping force equipment was then positioned and data recorded at different openings. Accelerometers were placed on the top and bottom contacting jaws (Fig. 2), and the trap was fired ten times. Afterwards the trap was again subjected to the clamping force test to determine if the clamping force of the trap had been affected by the firing of the trap due to spring overstress or frame bending.

Results

A few typical results are presented to demonstrate the system's functions. Figure 3 is a photo from the screen showing the velocity and displacement waveforms. Table 1 shows the clamping force of a Conibear 120 rotating jaw trap (Woodstream Co.) at openings ranging from 5 mm to 40 mm, in 5 mm steps. Figure 4 shows the momentum versus displacement graphs generated by the Asystant software for the Conibear 120 top jaw, bottom jaw, and both jaws combined.

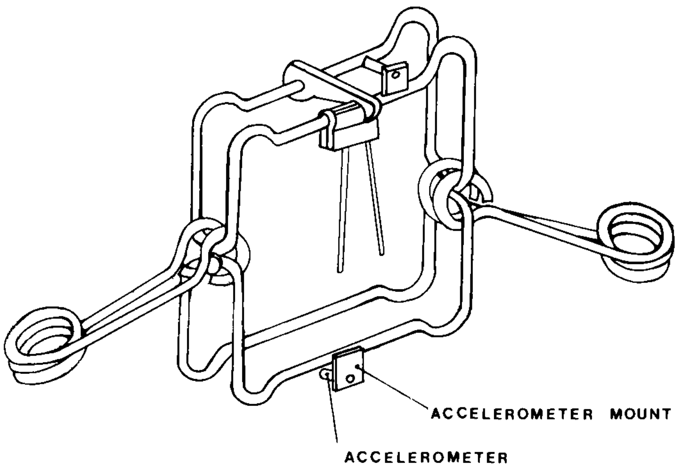

FIG. 2—*Typical trap showing location of accelerometer mounts.*

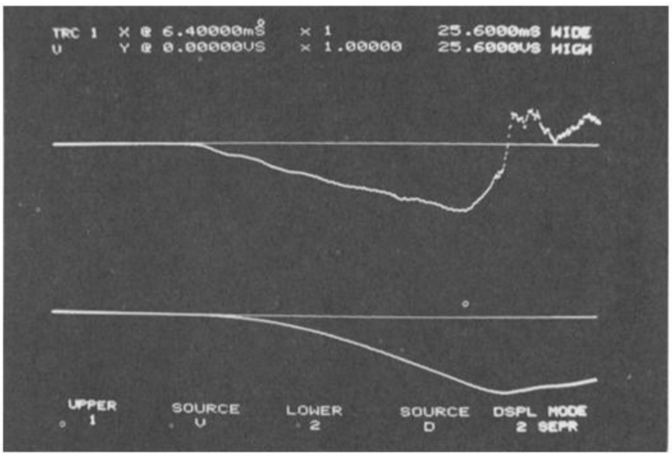

FIG. 3—*Photo of scope screen showing* (top) *velocity versus time and* (bottom) *displacement versus time for the firing of the Conibear 120 top jaw.*

TABLE 1—*Clamping force results for Conibear 120 trap, tested 8 October 1986.*

	Clamping Force Before Firing		Clamping Force After ten Firings	
Trap Opening, mm	Static Avg., N	Shake Avg.,[a] N	Static Avg., N	Shake Avg., N
40	167	196	178	202
35	187	216	191	211
30	205	231	203	230
25	214	242	196	224
20	168	178	138	154
15	117	129	107	123
10	40	42	0	0
5	0	0	0	0

[a]Shake Avg. denotes the clamping force exerted after the springs were shaken.

Discussion

The system developed for measuring the static clamping force has various advantages over the previously used system:

1. The load cell connected to the trap by a hook and threaded rod can set the trap opening at an infinite number of openings by simple adjustment of the nut on the threaded rod. To adjust the setting of the previously used system, it was necessary to insert shims to obtain the desired setting. Thus openings were limited to the combinations of the available shims and could not get any smaller than the actual size of the load cell.
2. The use of the hook rod arrangement allowed the trap springs to be loosened off, then released, yielding more than one measurement at a given opening. With the shims, extreme care would be necessary when performing this operation so that the shims did not move out of place.

The use of a digital analyzer to record the data and display results has many advantages over the chart recorder, tape storage system:

1. The data can be recorded and stored with few transfers of data, whereas with the tape storage unit there are many transfers of data where lengthly leads or poor contacts could result in loss of information.
2. The digital waveform analyzer allows the experimenter to read the results directly from the screen using a cursor without the approximations that were necessary when reading results from a graph generated by the chart recorder.
3. The digital waveform analyzer allows the output signal of the accelerometer to be viewed in a real-time state before the trap is fired. This makes it possible to know if an external signal is being picked up, or if a static build-up on the experimenter has been transferred to the accelerometer (a condition that frequently occurred). With the chart recorder tape storage system, this monitoring is not possible.

When firing the trap, noise was generated due to the metal to metal contact. Because of this, it was felt that the 2 to 3% maximum transverse sensitivity of the transducers could be treated as part of the experimental error.

The integrated use of the digital waveform analyzer, accelerometers, load cell, and analysis software permits an accurate determination of the momentum and clamping force of a striking bar killing-type trap throughout its entire motion. The use of one accelerometer on each striking bar affords monitoring of the movement of each striking bar. Although this is not important when both bars are identical, it is advantageous when the equivalent masses of the bars differ, thus causing each bar to move at a different speed. Securing the accelerometer mount to the trap with spot welds created problems in that the heat of the weld removed the temper from the jaw frame. When the trap was fired the non-reinforced jaws bent slightly where the mount was welded in place but did not affect the readings. Although the bending is not desirable, no other method could be devised to secure the accelerometer in place while allowing the trap to be set in the desired position. This problem could possibly be avoided by using a cooler MIG weld. However, access to such equipment is limited and expensive.

With the system developed here, it is now possible to perform quality control checks on mechanical traps. It is also possible to assess their killing potential according to established standards

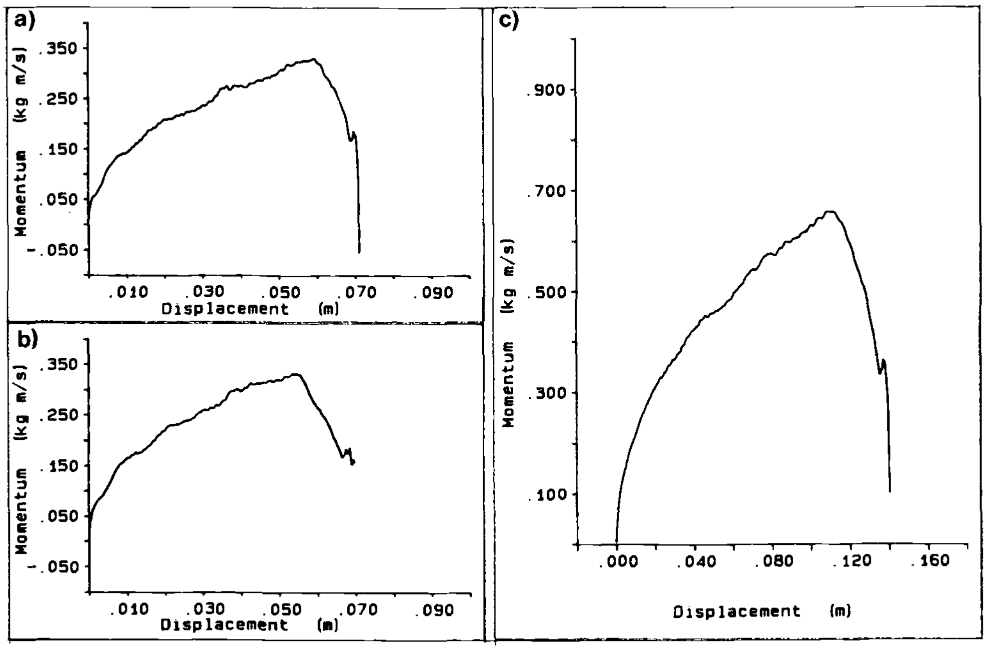

FIG. 4—*Momentum versus displacement of Conibear 120 Trap.* (a) *Top jaw.* (b) *Bottom jaw.* (c) *Both jaws combined.*

[*4,5*]. This system allows researchers to assess how modifications of trap designs optimize the killing potential of a trap.

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