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YOUNG SALMON ACOUSTIC COUNTER

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INTRODUCTION

For a proper management of salmon fisheries information on the amount of spawning escapements and the number of young fish travelling downstream for feeding in the sea should be available. This allows provision of more accurate scientific advice on the norms of withdrawal and a study of environmental effects on stock status. This information is also valuable in evaluating the efficiency of salmon farms and biological techniques of salmon cultivation. The most reliable information can be collected by using non-contact automatic counters. This paper describes a counter with acoustic transducers sounding the fenced water volume through which fish run. A simple design and signal processing procedure ensure acceptable accuracy of measurements with low operating power which facilitates its installation on rivers distant from a mains power supply.

Remote non-contact counters are widely used for quantitative assessment of young salmon. The methods are based on physical phenomena induced in electric, acoustic and electromagnetic (optical) fields by the passage of fish in the surveyed channel:

a) variation of conductivity in a part of water environment;
b) reflection of acoustic waves from objects at an active echo-ranging of the channel;
c) absorption and reflection of a flow of acoustic waves in the channel between transmitting and receiving acoustic transducers;
d) absorption and reflection of light waves in the channel between illuminant and photodetector.

It is a difficult task to unequivocally show advantages of a single method, so the choice should be based on specific conditions of operation. Counters with optical sensors have a simple principle of operation, which is based on counting the number of crossings of a focussed beam. Their resolution is the highest and they can count small-sized objects. However, their range is small, environmental effects on the accuracy of measurements are strong (ambient light, mud, sediments on sensor elements) as well as the influence of foreign objects in the water flow. Such sensors only respond to size, not to other physical properties of passing objects. Counters with electrode sensors are also affected by water properties and foreign objects, have low resolution, and their range is limited by the allowable electric field strength; too high a level can injure fish. However, they are sensitive to electric parameters in fish, therefore, a selection can be done by this feature. Counters with acoustic transducers are less susceptible to environmental effects, have a wide range of operation, can classify objects by acoustic reflection parameters and have high resolution, this suggests good prospects for their use.

METHOD

Acoustic systems for counting diadromous fish include scanning-pulse active sonars cutting the surveyed channel transversely by radial or parallel narrow beams. A design of this system is more complex than that of counters with optical and electrical sensors. Intensity of the transmitted signal should be high enough to compensate for two-way attenuation losses and to obtain sufficiently high echo/noise ratio. In practice when counting the running young fish in rivers and streams it is often necessary to set counters in sites located far from stationary power sources. In these conditions simple, reliable and low-power counting systems are required which can combine counting principles inherent in optical and electric sensors and noise immunity and range of operation in acoustic ones. The design of the counter is based on the principle of interruption of an acoustic beam between two transducers in the near field of a transmitting transducer. This is better from the point of view of energy expenditure, than working with echoes because a level of modulation of the acoustic beam arriving on the receiving transducer depends on the total amount of energy absorbed and reflected by the fish, allowing for losses due to attenuation and propagation in one direction only. Acoustic unit of the counter is a part of a hydro-transport line (natural or artificial) along which the fish travel. It is a counting chamber in the form of rectangular frame on opposite sides of which acoustic transducers are mounted. The frame is built in a net, set across the water flow. Dimensions of the frame can be adjusted so that spatial-temporal separation of fish is ensured. Maximum dimensions in a plane perpendicular to the water flow are limited by the near field of the transmitting transducer. The transducer is a ceramic type with high resonant frequency inperceptible by fish an, therefore, not affecting their behaviour. An acoustic field produced by such a transmitter is identical to that created by vibrations of a flat piston. If the size of transmitting surface is well above the wavelength, the transmission is a quasi-flat wave propagating as a limited beam with a base on the piston. While the distance from the piston increases, diffraction blurs the beam, which at a great distance changes into a multi-lobe diverging spherical wave. The beam starts to diverge, or the so-called far-field (Fraunhofer zone) at a distance of

$$r = a^2/\lambda$$

where a = side of transmitting system, λ = wavelength of transmitted wave. In the zone where $r < a^2/\lambda$, i.e. in the near-field (Fresnel zone) no strong dependence of the acoustic field on r is established. For a chosen transmitter the maximum distance at which the near-field can be assumed is approximately equal to 2 m.

Fig. 1 shows a circuit design of the counter. A self-excited oscillator produces a continuous signal of high frequency which is transmitted by one transducer and received by the other. This signal then arrives at a tuned amplifier and thereafter in detector 2 which forms constant voltage at a comparator input. At the other input a signal which has come through the scaling unit and amplitude detector 1 arrives. Scaling unit gain factor is chosen such that for given dimensions of the chamber window and surrounding conditions an output signal should be equal to zero. Simultaneously this circuit design provides for automatic compensation of variations in power supply, because the oscillator output signal is directly proportional to power supply voltage. When an object enters the chamber window, the comparator output signal changes, and, if this change exceeds the comparator threshold, a pulse occurs which comes to the counter via logic. An indicator with a capacity of 4 decades is a separate unit which can be connected to the counter for readings to be taken. In such a circuit false operation can occur from both air bubbles and chattering of the comparator during fish passage through the window. To eliminate these effects another identical unit is installed sequentially in the direction of the fish run at distance L. Signals from outputs of comparators are fed into logic circuits which produce a count pulse only when signals from both units arrive. Distance L can be chosen such that a count pulse is produced under conditions that $l < L$ or $l > L$, where l is the fish length. This will provide the opportunity for selection of fish by largest or smallest size.

Power consumption by one counter channel without the indicator does not exceed 0.5 W. The indicator is supplied with its own power source. Deviation of amplitude modulation level at the amplifier output due to fish passing through different parts of the window varied up to 10-fold. It depended on size and shape of transducers and the distance between them, also fish size and their behaviour in a window zone. Deviation was found to be the lowest for circular transducers. However, in this case the acoustic beam width increases thus reducing the resolution. Finally rectangular transducers were chosen and smoothing of spikes was carried out by filter low frequencies at the comparator output at a time constant of 0.5 s.

No reliable criteria are established for setting the comparator threshold, therefore, it is set by an operator monitoring the operation in each specific case individually. In future this drawback is intended to be removed by the introduction of microprocessors for more complex processing of signals from detector outputs and subsequent logic processing for estimation of direction and speed of the fish run.

RESULTS FROM FIELD TRIALS

The counting chamber was mounted in a throat of a fyke net and tried at a counting fence set across the Luvenga river flowing into the Kandalaksha Bay of the White Sea. Readings were verified by comparison with observations by underwater TV camera and results from manual counting of young fish captured by the counting fence. Two modifications were tried - with one frame and with two frames. In the first instance a series of check countings of 5-10 cm down-stream migrants showed that the error varied from 10% to 40%. Maximum error was reduced to 20% when fish which had passed through the window in an opposite direction were included, based on TV camera observations. Other errors were introduced by simultaneous crossing of the acoustic beam by several fish and by choking of the channels by leaves and grass. Increase of window area reduces accumulation of foreign objects, however, this will also increase the probability of several fish passing simultaneously through the window. To enhance the passing capacity several independent counters were mounted in the net. In the second instance the error varied from 3 to 15%, errors due to overestimation were excluded. Capacity of the built-in batteries was adequate to maintain 7 days of operation.

Tentative results from these trials suggest that the counting system of this design shows promise. Further work to improve processing circuit will enhance the reliability of information gathered.

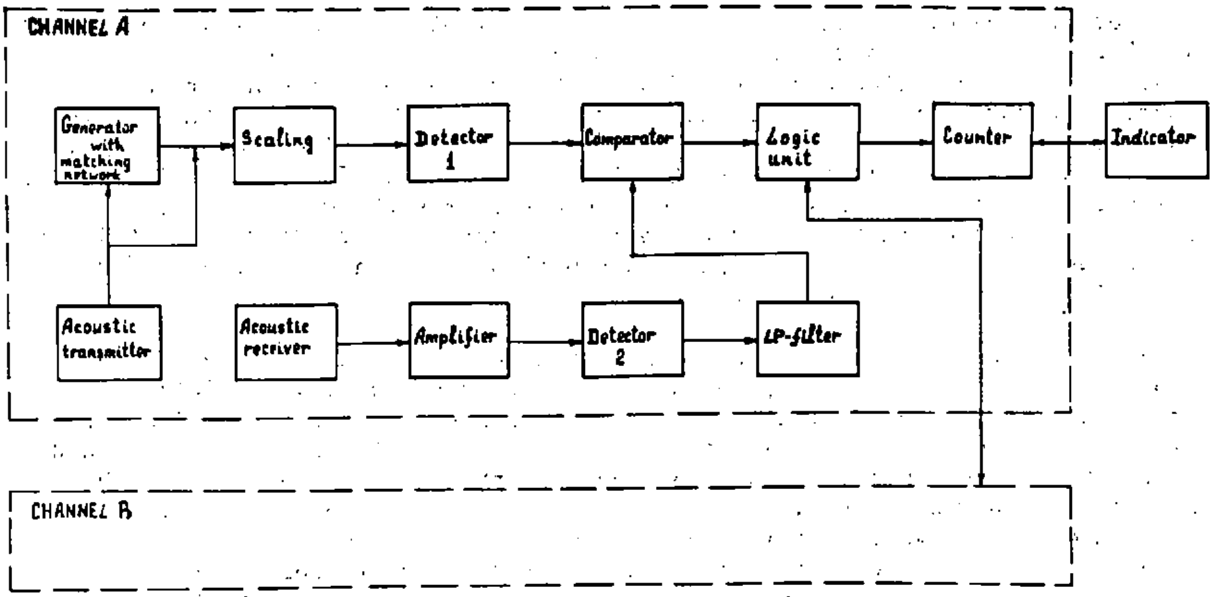
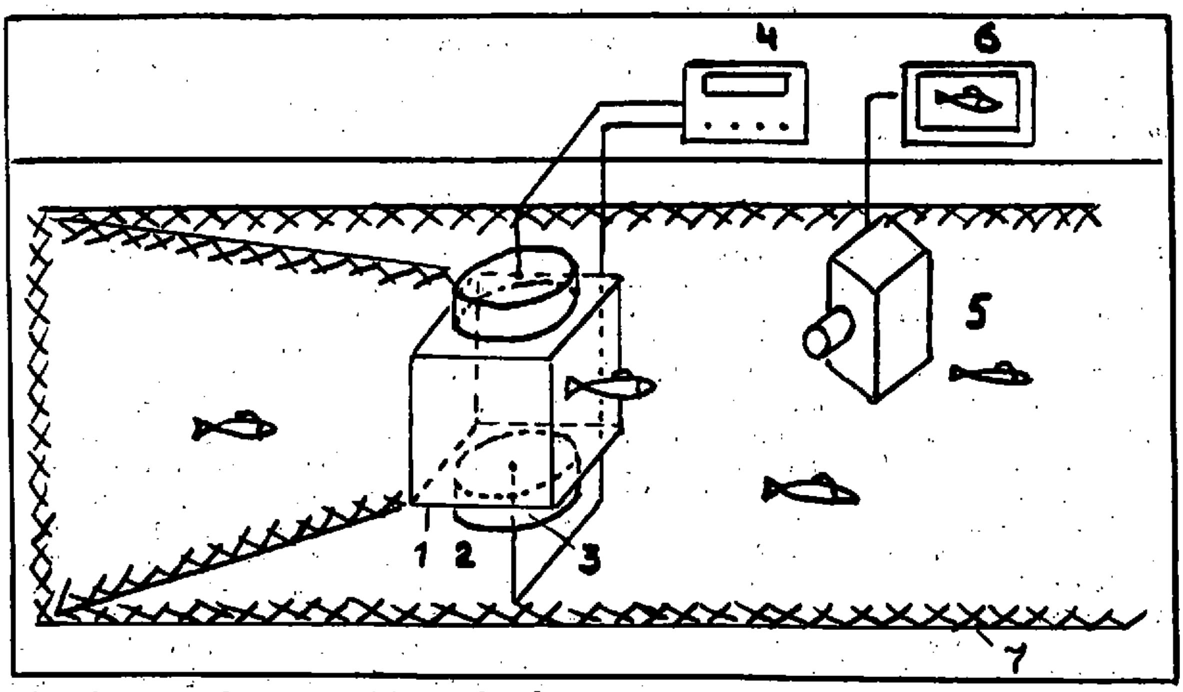


Fig. 1 Circuit design of the counter.



1. frame; 2 - counting chamber; 3 - antenna; 4 - counter;
5. TV Camera; 6 - TV set; 7 - fyke net

Fig. 2 Diagram of the counting chamber mounted in a fyke net.