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A Sonar Fish Counter

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A reliable and accurate means of counting migratory fish in rivers is essential for efficient fishery management and investigations of fish migration. Hitherto this has been achieved by confining the fish passage to a narrow tube so that observation of conductivity changes[1] gives a good indication of the passing fish. It is felt, however, that to interfere with the channel in this way may affect the migration itself, and that counting should be done in a more normal river channel. Visual observation of fish in a wide channel is difficult even under the best conditions and is impossible in the dark or when the river is discoloured during flood conditions. The use of sonar seems to offer the best solution to the detection of fish under most conditions. A sonar equipment has been developed in the U.S.A.[2] based on acoustic transducers set along the river bed at intervals across the river. This equipment appears to give reasonable results in wide Alaskan rivers where salmon run in very large numbers, but is considered unsuitable for British conditions, especially in rivers with large amounts of weed and floating debris. This equipment has no directional properties and can consequently be really effective only when the fish movement is entirely in one direction. A sonar method of counting fish moving up and down stream, using a different principle, has been developed in the Department of Electronic and Electrical Engineering at the University of Birmingham during the last three years.

This new technique for counting fish migrating up and down stream is based on the ability to detect the presence of a fish in an acoustic beam directed across the river. The direction of motion is determined by using two beams separated by a small distance and observing the order in which a fish passes through the beams. The advantage of the equipment over existing non-acoustic methods of counting fish are that it is designed for use in moderately wide, open channels; it is capable of counting several fish moving up or down stream simultaneously, and it can discriminate between echoes originating from fish and those from certain inanimate objects such as weed.. Although the present counter requires a smooth river bed approximately rectangular in cross-section, work is proceeding which may enable the system to work in normal river beds. The equipment consists of ceramic transducers mounted on the river bank with a shore-based electronic processing unit.

The full river cross-section is searched acoustically by arranging the transducer beams as shown in Fig. 1. This effectively gives two complete acoustic curtains across

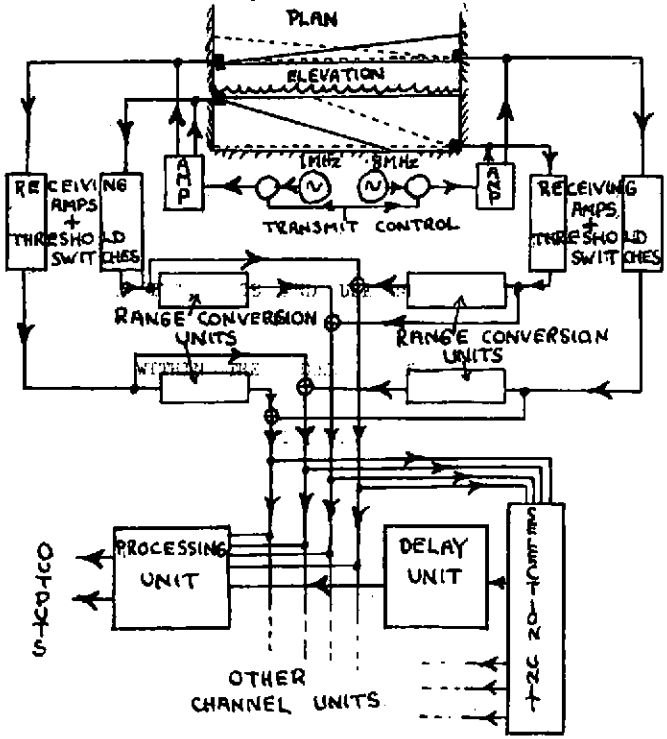

Fig. 1. Block Diagram of Electronics and Beam Pattern Arrangement.

the river section and yet the acoustic energy is mostly confined to the water to be searched. The surface transducers are mounted in a floating housing so that the system automatically adjusts itself to maintain full coverage of the water with variation of river level. One set of transducers gives full coverage over a depth range 2 : 1 and if greater variations are required a second set of transducers can be used. Since transducers on opposite banks of the river illuminate each other, the direct path would appear as a target at mid-river range. This is overcome by using transducers at different frequencies with tuned receiving amplifiers. In the present equipment the two frequencies are 1 and 0.8 MHz. The tuned receiving amplifiers have time-varying gain to equalize spreading and attenuation effects. The decision as to whether an echo is a target is determined by voltage-threshold switches. Two different thresholds are used so that the fish can be divided into two sizes, and after being further processed the output of each switch triggers a monostable circuit to generate a target pulse, the width of which indicates the magnitude of the target echo. This enables the processing which follows to be digital.

The digital processing unit is controlled by a 128 bit counter the cycle period of which is made equal to the range time of the opposite transducers. The cycle period can be adjusted by altering the counter input frequency. The counter is then used to control the transmission rate; all transducers being pulsed at the same time, as well as being used in the processing system. Logic circuitry follows the threshold switches to eliminate echoes from dispersed targets, and if the echo satisfies the discriminator a pulse of a fixed length is fed either to the range conversion unit or directly to the channel unit depending upon the range of the target.(see Fig.1) The range conversion unit stores target pulses obtained from the first half of the transducers range. These are then destructively read out at the same point in time as the opposite transducer would see the target if it was common to the two accustic beams. The outputs are combined with the appropriate target pulses received during the second half of the transducers range. This means that the transducers have a common range origin as far as the processing unit is concerned so that a target illuminated by the two opposite transducers is processed as a single target. The target pulses after the combining then select their own range interval delay unit and processing unit. These two units form the channel unit.

The selection of the channel unit is controlled by the selector unit which allows target pulses which have just appeared to select a free-channel unit, and prevents target pulses in an already selected range interval from selecting another channel unit. Each target pulse selects its own range interval delay unit which then generates the same range interval at the same range during subsequent transmissions. The range interval delay unit is held engaged and only allows target pulses which occur within a fixed range of the selecting pulse to be routed into the associated processing unit. The range interval delay unit looks for further target pulses in the fixed range gate and whenever a target pulse occurs the unit adjusts itself so that the pulse occurs in the middle of the range interval. This means the range gate will track the target if it moves in range. The presence or absence of a target pulse in the particular range interval is used to control the contents of a shift register and a fish is said to be present when the ratio of 1's to 0's in the register exceeds a selected fraction. When a fish leaves one beam the equipment looks for a fixed interval of time at the particular range interval to determine whether this fish moves into the other beam. The up-and down-stream pairs are routed to separate shift registers and the sequence of switching of the shift register ratio-comparators gives the direction of motion. The output is fed to a recorder which can be either an electro-mechancial counter and/or a time recorder such as punched tape. The number of individual fish that can be counted simultaneously depends upon the number of channel units added to the equipment. The processing unit determines from the target pulse-width whether the pulse originated from a large fish or a small fish. The equipment is constructed with integrated circuits, occupies a 19x12x9 in pack, and requires 16 W of electrical power.

The counter is unsuitable for use immediately down stream of any waterfall or turbulent rapids due to the volume reverberation from the air bubbles in the water. The minium distance the counter must be sited downstream of the above obstacles depends on the average river velocity and level. The other factor which is important is the volume reverberation due to suspended solid matter when the river is in flood condition. Measurements made to date

show that the worst condition is at the peak of a flood when few fish are likely to run. Even under these conditions and with transducers suitable for a river 16m wide and 1.5m deep, it is still possible to detect a 7" dia. sphere which is equivalent to the target strength of a medium sized salmon.

Extensive trials have been carried out with the counter and preliminary investigations into the factors affecting the counter have been made. The trials carried out so far have shown that the counter is an effective fish counter but due to the difficulty of obtaining a site with a large run of salmon the data is insufficient to put any confidence limits on the counter. Modifications in the light of experienced gained during the trials have been carried out and the equipment is now ready for long term trials.

(1) Lethlean, N.G. (1951-53) An investigation into the design and performance of electric fish screens and an electric fish counter. Trans. R. Soc. Edin. Part II (No.13) p.479.

(2) Bendix Corporation