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DETECTION OF INTERNALLY TAGGED FISH WITH SPECIAL APPLICATION TO THE ATLANTO-SCANDIAN HERRING

by

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Summary

The paper describes the operating principle and use of a new machine for detection and sorting of internally tagged fish. The machine has been used in the calculation of the Atlanto-Scandian herring stock size. Fixed installations at major fish landing sites with a more advanced sorting machine are planned.

Introduction

Tagging is accepted as one of the most reliable methods available for the calculation of stock size and migration patterns of fish. In Norway tagging is regularily used on all important species. Tagging is done either external or internal. The external tags - which are either a coded flag, a capsula fixed to a fin - or a code burnt or frozen on to the fish skin are designed to be discovered on vision by the fisherman himself or by people in the fish processing system following the landing. Motivated by an altruistic way of thinking or by the expectation to receive a minor premium, the finder returns the tag to the Institute specifying where he found it.

For the external tagged fish the tag is frequently a difficult burden to deal with. The point of fixation may become infected and a variety of weed may fix to the tag often increasing its hydraulic resistance to unbearable levels.

Internal tagging is done by inserting a coded foreign body into the fish tissue on a part of the fish where the implantation will not seriously interfere with the normal body functions. Internal tagging has many advantages from the fish's point of view. Its skin will not be penetrated after the insertion wound has healed, so neither infection nor increased swimming resistance will take place.

The basic problem when using internal tags is the reliable tag recovery.

At the Institute of Marine Research internal tagging with coded stainless steel marks has been in regular use since 1948 on species like herring, mackerel and capelin that are normally delivered to oil and fish flour factories. The recovery of the tags has been obtained by using pick up magnets at the end of the processing chain.

During the last 5 - 10 years an increasing part of the catch of herring and mackerel has been delivered for direct human consumation. Simultaneously the necessary regulations of the fisheries has increased the needs for improved population abundancy calculations. Both these factors have vastly increased the need for an efficient device for detecting and sorting out internally tagged individuals from the stream of fish delivered to a fish landing place.

Detection and sorting equipment for internal tags have been described by several authors. (Ref. 1, 2, 3). At the Institute of Marine Research one wanted to continue the use of traditional stainless steel tags made by Bergen Nautik with which a good fish survival percentage have been obtained.

The Bergen Nautik tags are delivered in different sizes depending on fish size. The most popular tag - the so called "Herring tag" - measures appr. 20 x 4 x 1 mm and weighs 1 - 2 grams.

The Institute of Marine Research therefore in 1976 started a development project which aimed at designing a general internal tag retrieval machine for permanent or semipermanent mounting at important fish landing sites.

The general specifications for the machine were stated as:

1. It must reliably detect and sort out the presently used standard Bergen Nautik tags.

2. It must work reliably in all kinds of unfavourable environments that exist on a typical landing place. - This means it must stand against moisture, changing temperatures, changes in mains supply, vibrations, abbrations of fish skin and external magnetic and electrical fields.

3. It must have a larger sorting capacity than the reception capacity of the landing site itself in order not to delay the ordinary work.

4. If it for some reason ceases to function, it must not cause a stop in the succeeding production stages.

Financing of the project was partly granted by the Norwegian Council for Fishery Research.

A development group with people from The Institute of Marine Research, The Chr. Michelsen Institute and Trio Engineering Inc. was formed in order to design a sorting machine according to the given specifications.

Choice of operating principle.

The sorting machine needed must consist of 3 main components:

1. A tagging detector
2. A sorting mechanism
3. A mechanism for transporting the fish through the detector and sorting mechanism.

The work first consentrated on the development of the tagging detector.

From an instrumentation point of view the tag has the following possible detectable properties:

1. It is made of metal with known electric resistance.
2. It is slightly permanent magnetic. The remnant magnetism may be amplified by exposing it to a powerful magnetic field before the detection.
3. It is paramagnetic.
4. It has a larger specific weight than the fish.
5. It is positioned in the fish belly normally with its length axis parallel to the fish length axis.
6. During sorting it moves at a speed of 0,3 - 3 m/sec..

In the scheduled sorting machine the presence of a tag in a fish must be detected within a time interval of 50 - 60 milliseconds at a distance of up to 20 - 30 cm. Hence only a detection principle based on magnetic phenomenas associated with the tag were practical to follow up.

The detector hence had to be based on sensing of the tag's magnetic properties - which means either:

1. Detection of the tag's self-created magnetic field.

or 2. Detection of the tag's ability to make changes in either the Earth's magnetic field or in an artificially induced magnetic field.

Both principles have been tried.

The magnetic field from the tag originates from a mechanical stressing of its magnetic domenes during the rolling and cutting process. At a distance of 20 cm its relative field strength is appr. 0,5 - 1 % of that of the earth's magnetic field.

To detect this magnetic field a highly sensitive magnetometer was developed. As a quideline for the design principles for design of flux gate compasses were used. Fig. 1 shows the design principle.

A toroidal shaped core of high permeability sheet metal is alternatively brought into saturation by means of an AC-current through the excitation coil. When the core is placed in a region with no external magnetic field, the saturation will be equal for both negative and positive currents, and the flux from the coil will be evenly distributed around the core. If an external magnetic field adds to the core, the flux will add and subtract on the both sides. Hence an uneven field distribution developes. A pick up coil wound around the core will detect a 2. harmonic component of the excitation in proportion to the strength of the magnetic field. This 2. harmonic component is filtered out and converted to an analogue signal that can be used to trigger the sorting mechanism.

During the practical testing of this sensor it was concluded that the signal to noise ratio was too small to make the system work reliably in the field.

The second alternative - the use of tag-induced changes in the surrounding magnetic field - proved more convenient.

Due to its paramagnetic properties a tag will increase the strength of a magnetic field that surrounds it. The tag will also tend to reduce the magnetic resistance for a magnetic flux that passes it.

Both these properties can be utilized in a "magnetic bridge" circuit.

Fig. 2 shows the detection principle.

Around a plastic tube - with a diameter of appr. 20 cm are wound three coils A, B and C respectively.

Coil B - in the middle - is excited with an AC signal. The flux from coil B will induce an AC signal in both coil A and coil C. A and C have the same shape and the same number of windings. Hence the induced signals in A and C - denoted by U_A and U_C respectively - will be equal. In the succeeding electronic circuits U_A and U_C are rectified and subtracted. When filled with magnetically indifferent materials like air, water and untagged fishes, the difference between U_A and U_C will be close to zero. If a fish containing a tag passes the tube, first the magnetic resistance in A diminishes. Hence the magnetic flux and inevitably also U_A will increase and $U_A - U_C$ becomes positive. When the tag passes C, the induced signal U_C will increase and $U_A - U_C$ becomes negative. Fig. 3 A shows the characteristic signal shape for a paramagnetic body that passes through the tube.

The passage of a diamagnetic material or the passage of a paramagnetic material in opposite direction will cause a signal as shown in fig. 3 C. The correct tag signal pattern can therefore be used to improve the signal to noise ratio.

Fig. 4 shows the first detector that was designed. It has a length of appr. 100 cm and an inner diameter of 20 cm. For simple and rough design the center coil C is excited by 50 Hz signals from the mains supply. A voltage reducing transformer is put between to make the excitation level harmless in case of damage to the electrical insulation.

In the succeeding circuits following the detector $U_A - U_C$ is amplified in an instrumentation amplifier.

Slow changes in the coil geometry due to heating and changes in mounting may change the U_A - U_C difference. To prevent drift the instrumentation amplifier is followed by a zero level controller which automatically compensates for slow changes in U_A and U_C and neglects fast changing signals that may be caused by a passing tag. Following the zero control circuit is a logical signal processing stage. The purpose of the logical signal processing stage is:

1. Identify the characteristic shape of a tag (like shown fig. 3 A).
2. Generate a time delay to allow the moving tag to reach a position where it can be reached by the sorting mechanism.
3. Activate the sorting mechanism and keep it active until the tagged fish is removed from the stream of fish.

Fig. 5 shows the basic stages in the processing.

A possible tag is detected as the U_A - U_C cross the low reference level. Ref. 1. A time delay T_1 - that corresponds to the maximum time a real moving tag can possibly stay inside the coil - is generated. If the triggering is caused by a paramagnetic material, it will move with the speed of a fish, and Ref. 2 will be crossed within 1 - 2 seconds. When Ref. 2 is crossed, a new impulse lasting T_2 seconds is generated. If T_1 and T_2 occur simultaneously, a delay time T_3 is generated. As T_3 ends, an impulse to the sorting mechanism lasting T_4 seconds is generated.

Sorting mechanism.

Fig. 6 shows the selected sorting mechanism. Parallell to the direction of the fish flow a vertically hinged gate is mounted. The gate is opened and closed by an air piston which is driven by compressed air from a separate, portable compressor. The flow of compressed air from the source to the piston is controlled by a magnetic valve which is activated by signal T_4 from the logic circuit just described.

On a signal from the logics, all fish that passes the gate when the gate is activated is pushed out to one side.

On the first machine that was made the fish to be controlled is loaded into a container and lifted appr. 2 meter up in the air by a transport band. The fish then slides through the detector coil, passes the sorting mechanism and finally leaves the sorting machine for transfer to containers, new transport bands etc..

Practical results.

The machine described was in particular built for detection and sorting of the Atlanto-Scandian herring. After being close to extinction a few years ago, this species is slowly growing. To monitor its development a close surveillance of the stock size has been found necessary. To estimate the abundance of Atlanto-Scandian herring the Institute was allowed to catch 500 tons of it during a cruise with M.S. HAVDRØN in february/march 1977.

The cruise started in Tromsø and ended in Bergen. Before being delivered for consumation, the entire catch was sent through the sorting machine. After an initial problem with moisture penetrating the detector encapsulation, the sorting machine worked very reliable. During the cruise a total of 17 tagged individuals were discovered and sorted out. As length and tagging place is known for each tagged individual, the growth, general condition and migration route for the refound herring could be easily measured and calculated.

Based on the measured consentration of tagged fish referred to the number of implanted tags - taking into account the estimated mortality in tagged fish etc. the abundance of Atlanto-Scandian herring was estimated to be appr. 0.2 million tons (Ref. 4).

The instrument performance was continuously controlled during the cruise by mixing externally marked test fishes containing internal tags with the unsorted fish. A total number of 500 test herrings were put into the system. 498 of them were promptly sorted out giving an efficiency very close to 100 %.

Further plans.

For the autumn 1977 a permission to catch up to 10 000 tons of herring has been given to the Norwegian coastal fishers. To control the population with a wider statistical input material a permanent installation of 3 sorting machines along the coast has been planned. The new machines will be designed as shown on fig. 7. The catch will be loaded on a horizontal transporter and move through a rectangular shaped detector coil. A tachometer which gives an impulse for each cm the transport band moves, will feed a digital delay line of 50 steps. 50 cm away from the detector is a pneumatically driven shuffle which sweeps across the band once when an impulse from the delay line excites it. A tagged fish will thus move exactly 50 cm along the band after detection, and then be swept from the band into a plastic bag. The bag will later be frozen by the factory staff, and on a convenient occasion sent to the Institute of Marine Research for examination.

Based on the good results with the prototype we feel very optimistic on the outcome of our project. We expect to be able to design a sorting machine which can work unattended for long periods and simultaneously can produce very reliable return tag information. In the first run it will work with herring, but in the long run for all kind of consumation fish.

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Fig. 1 : Principle for flux gate type magnetometer.

Fig. 2 : Principle for the magnetic bridge.
Coils A and C are symmetrically excited from coil B.
The net resulting induced signal $U_A - U_C$ is normally zero, but changes if the magnetic resistance in either A or C varies.

Fig. 3 A: Typical "correct" signal as received when a tagged fish pass the detection coil.

3 B: Inverted, amplified signal.

3 C: Not accepted signal.

Fig. 4 : The original tag detector.

Fig. 5 : Basic stages in the tag detecting logic circuit.

Fig. 6 : The pneumatically operated sorting mechanism mounted in the complete machine.

Fig. 7 : Design of the new permanently installed sorting machine.

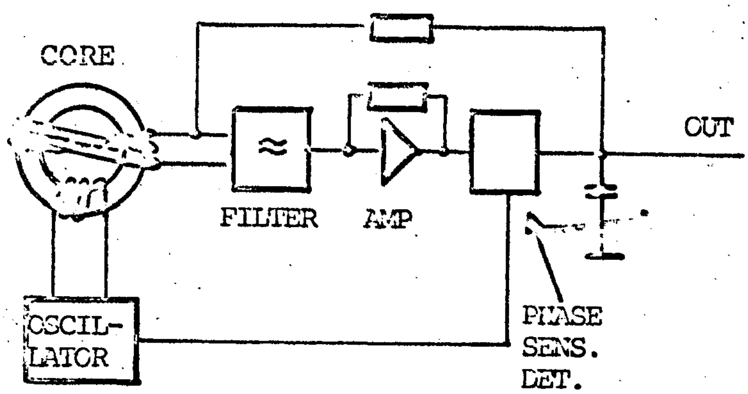

Fig. 1.

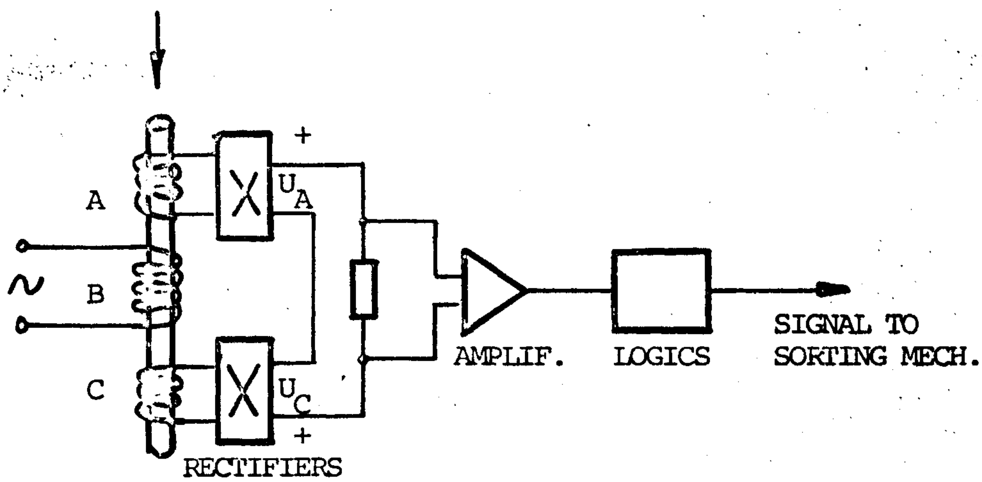

Fig. 2.

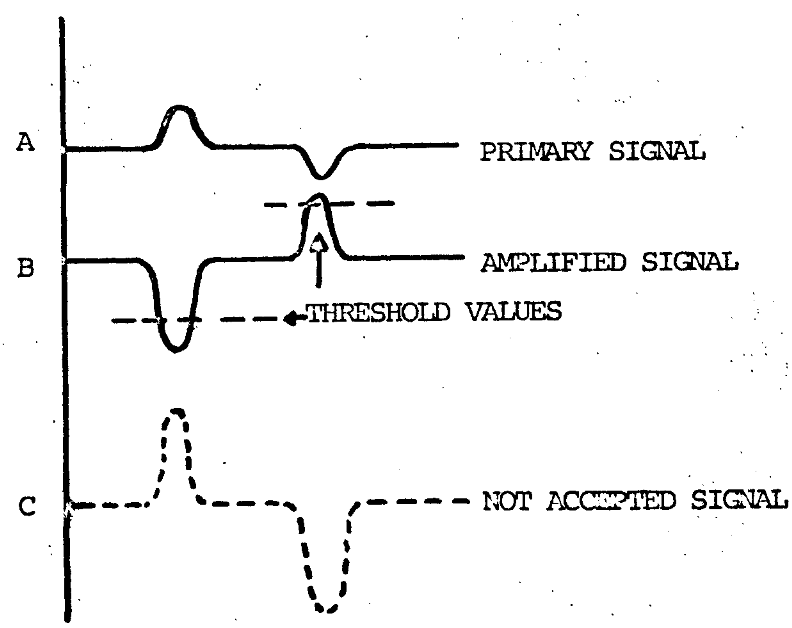

Fig. 3.

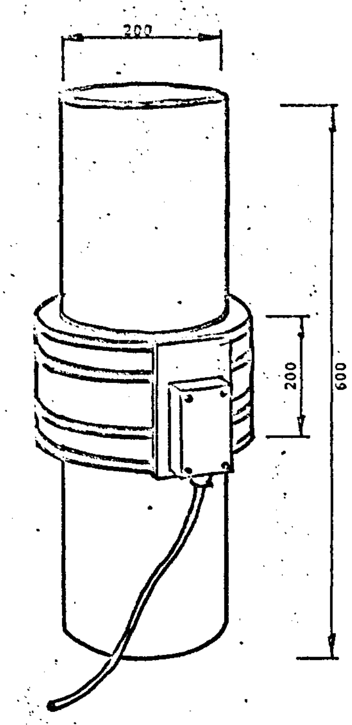
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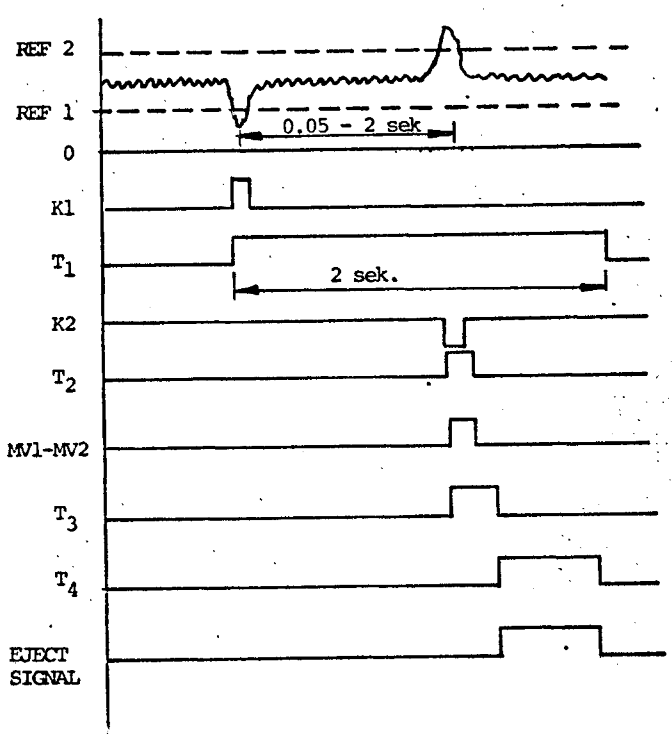
Fig. 4.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K1
T_1
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K2
T_2
MV1-MV2
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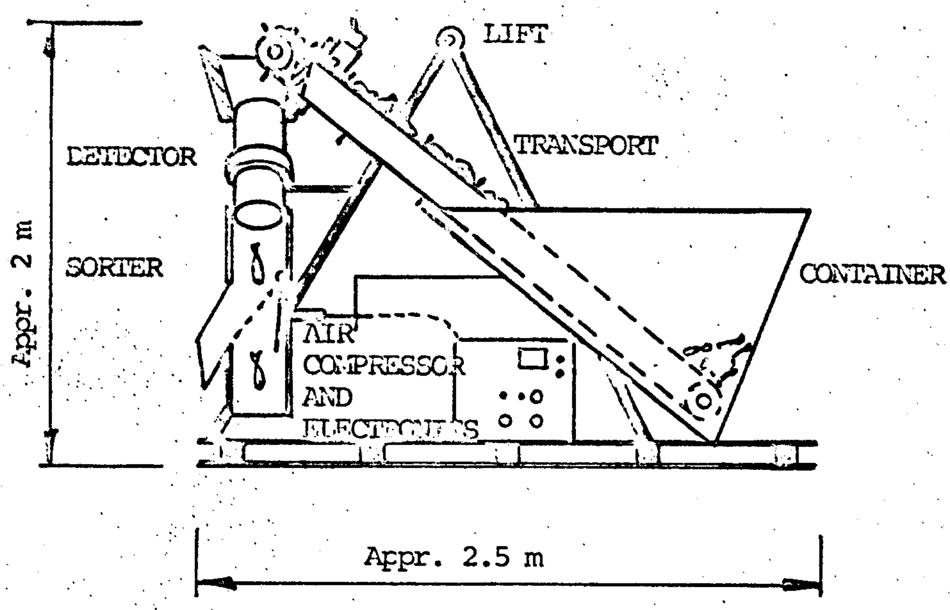
T_4
EJECT SIGNAL

Fig. 5.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TRANSPORT
DETECTOR
SORTER
CONTAINER
AIR COMPRESSOR AND ELECTRONICS
Appr. 2 m
Appr. 2.5 m

Fig. 6.

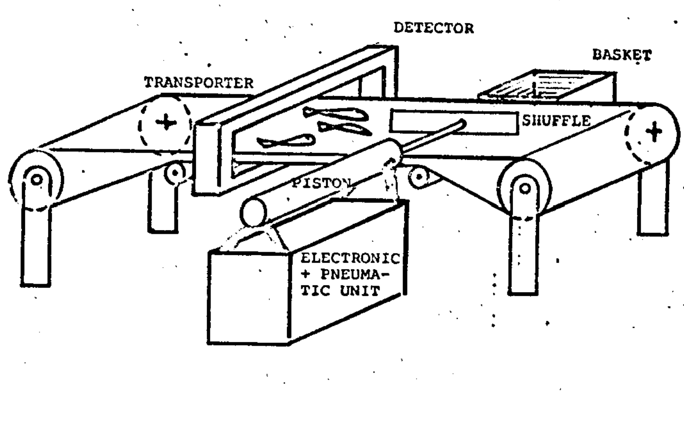
DETECTOR
BASKET
TRANSPORTER
SHUFFLE
PISTON
ELECTRONIC + PNEUMA- TIC UNIT

Fig. 7.