DISTANCE KEEPING AND FREQUENCY SYNCHRONIZATION IN SWEDISH HYDROGRAPHIC SURVEYING (PARALLEL SOUNDING) — 1972

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Ever since parallel sounding techniques were first used in hydrographic survey work in Sweden about 15 years ago one of our chief objectives has been to develop an instrument that would supply the helmsman of each side launch with information indicating whether or not he is at the correct distance from the survey ship which is responsible for the position of the entire survey group.

In Swedish waters it is often necessary to conduct hydrographic surveys with echo sounding line intervals of 25 metres or less in order to guarantee full bottom coverage. Previously, distances of 25 and 50 metres were kept, using glass prisms, although results were often less than satisfactory. Radar has been used when longer distances (100 and 200 metres, or more) were involved. This method, however, is not so practical, as the desired measurement is obtained at the far end of the distance being measured, and thus very intensive VHF radio communication between the ship and its six or eight side boats is necessary. The delays due to the need to apply steering corrections are also inconveniently long.

In 1966 the Swedish Hydrographic Department initiated the development of distance-keeping equipment incorporating left-right indicators in all launches. The first generation of this equipment was developed by a Swedish electronic company.

The 1972 equipment, developed by that same electronic company and the Swedish Shipping and Navigation Administration in close collaboration, is now in operational use. The basic principles are the same as those previously used, but the technical design is entirely new. Moreover, the possibilities of the equipment have been expanded, so that the 1972 version provides not only distance-keeping information but also signals controlling the fathometers, and this enables all the fathometers in the group to *run* at exactly the same speed of rotation and also to *transmit* exactly at the same instant so as to eliminate interference from fathometers in neighbouring side boats.

DISTANCE KEEPING

The distance keeping is carried out by measuring the phase difference between two signals, both of which are transmitted from the survey ship. One is a radio signal and the other a sonic signal travelling through the water. Because the velocities of propagation in these two media differ widely, very clear information is obtained about variations in distance.

The pulse repetition rate of the two signals depends on the velocity of sound prevailing in the water at the time they are transmitted. Signals through water form wave fronts that spread out on both sides of the survey ship. Radio waves, synchronized with the water pulses, are also transmitted by the survey ship, thus making it possible to indicate in each launch the difference in arrival time between the two pulses. This time difference is read from a linear scale left-right indicator to within ± 5 m from the correct distance. This indicator has symmetrical full scale graduations, which means that the deviations are of about ± 15 m from the prescribed distance (Figure 1).

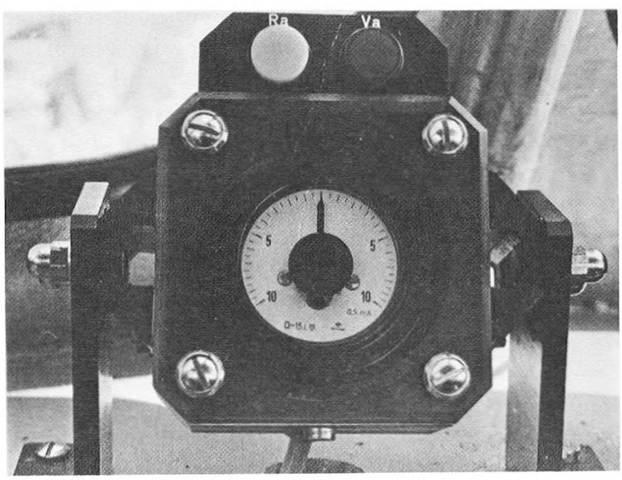
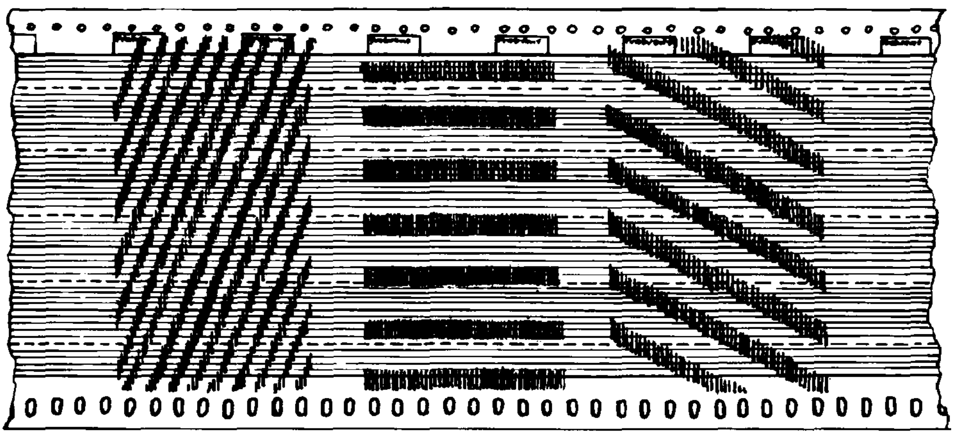


FIG. 1. — Left—Right Indicator.

In addition to the distance-keeping signal, the radio signal accommodates several other items of information that are useful to the launches.

Even in earlier versions we used the radio channel to send the fix-marking signal for the launch echosounders. Originally, it was given manually when lane crossings were made, but it is now sent automatically by feeding the hyperbolic crossing system into a programmable marking unit. We retained, of course, the manual marking option.

If the marking signal is chopped in synchronism with the pulse repetition rate of the ship's echosounding pulses valuable information is obtained in the launches. This chopped radio signal is fed into the launch echosounders and thus they can be adjusted for correct velocity. This velocity is indicated on the recording paper by a pattern that is either horizontal or inclined (Figure 2).



Too slow Correct Too fast

Fig. 2. — Echosounder recording paper.

FREQUENCY SYNCHRONIZATION

It quickly became evident that it is possible to use these signals for controlling the speed of rotation of the motor driving the launch echosounders. Each of these echosounders produces a special control signal. Both this special signal and the chopped radio signal are received by an electronic circuit incorporated into each echosounder. This circuit transmits an error signal which is used to control the motor driving the associated echosounders.

As a result, all the echosounding equipment used in the surveying group — which we call the "sounding rake" — runs at *exactly the same speed.*

Unfortunately, the amount of noise and interference from the echosounders, particularly if the distance between boats is small, often blurred the diagrams making them difficult or even impossible to evaluate. There is only one good way to eliminate this interference, and that is to *transmit the sounding pulses from the echosounders all at the same instant.*

Frequency synchronization has therefore been built into the distance-keeping system, and today all Swedish echosounding surveys are carried out both in synchronism and in phase. The first signal to arrive back at each echosounder after the pulse has been transmitted is in nearly all cases the echo from the bottom vertically underneath the boat. All other signals arrive later, and their effect is merely to add to the "shading" representing the bottom profile on the recording paper.

It should be mentioned that the equipment can be supplied either as a complete distance-keeping/frequency-synchronization system or else as a system for frequency synchronization alone.

EQUIPMENT

Transmitter

A few words about the different units. The transmitter (Figure 3) is built up on printed-circuit boards incorporating the latest electronic improvements, and all circuits are housed in a sturdy box. The programming unit and most of the other electronics are integrated circuits. The transmitter for the sonic signal comprises conventional semi-conductor components, while the radio equipment consists of mass-produced parts and components of Danish make. The equipment is operated by us at 439 Mc about 1 watt. Power output for the 50 kc sonic pulse is about 200 watts. Naturally it is also possible to connect an output amplification stage to

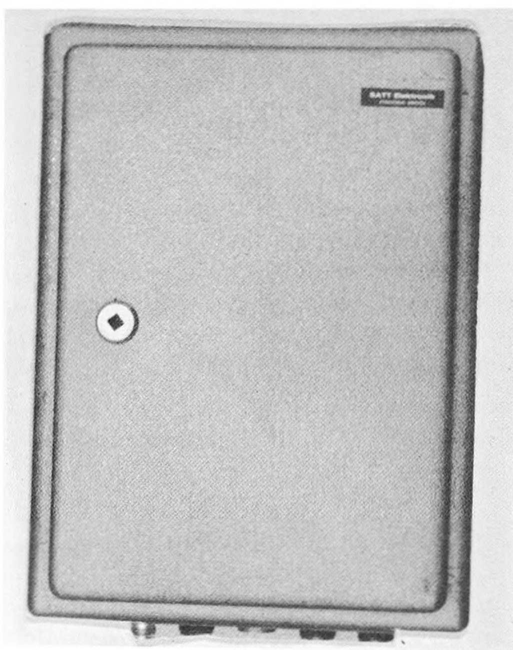


FIG. 3. — Transmitter.

the transmitter in order to provide for a longer distance to the furthest sideboat since it is ofien the water signal that limits the range. Total power consumption for the transmitter is about 40 watts at 24 volts.

The control unit can either be built into the equipment or, as in our case, be a separate unit.

The transmitter's pulse rate is controlled from the very accurately adjusted Atlas Deso 10 echosounder in the survey ship, but in the event of this echosounder being stopped, the programming unit in the transmitter takes over this control function.

For the sonic signal, the design of the transdueer has introduced some problems for which it is difficult to find any standard solution. We ourselves have resolved this problem by providing our smaller survey ships with a transducer built into the keel. Our largest survey ship, the *Johan Månsson*, is equipped with a transducer mounted on a 100-mm diameter projectable pipe. The overall length of the pipe is 1.2 metres, and it normally projects about 0.5 m into the water beneath the keel where it is less likely to suffer from interference. The sonic signal is more vulnerable to disturbance than the radio signal. However, experience has shown that it is at the receiving end that the signal is the most often disturbed, due to propeller turbulence emanating from the intervening launches. This can, however, be mostly eliminated by fanning out the launches in a gently curving pattern. The equipment was designed for change-overs of lane-to-lane distance of 25, 50, 100, and 200 metres. Last summer, however, we used a maximum distance of 400 metres and encountered no significant problems at 12 or 15 knots.

Receiver

The receiving equipment (figure 4) is mounted in a watertight casing, and is designed for operation under the worst conditions at sea. It measures 25 × 15 × 10 cm and weighs 2 kg. This part of the equipment is also built up on printed-circuit boards, and to a large extent consists of integrated circuits. Relays and certain transformers have now been replaced by photo-couplers.

The signal obtained from the receiver passes to the steering indicator and to the echosounder where it is used for pulse synchronization. The left-right indicator (Figure 1) is provided with warning lamps that will indicate the absence of either the radio or the sonic signal. The instrument itself is provided with an anti-vibration rubber mounting and is of rugged design and construction.

The receiver operates on 24 Volts and power consumption is 8 Watts.

The element that receives the sonic signal is enclosed in salt-waterproof material which, in turn, is moulded into the plastic of the keel of the launch. An outrigged mounting — an arrangement that is attractive primarily because of its simplicity — has undergone trials that yielded excellent results. On the other hand, some sort of centreboard mounting would, without doubt, provide even better results. However, our shipbuilders and those who have to hoist the launches aboard the survey ship have protested, and we electronics people do not always have our own way.

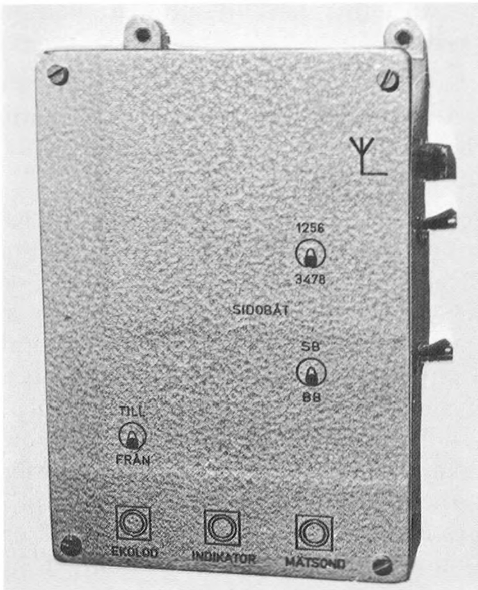


FIG. 4. — Receiver.

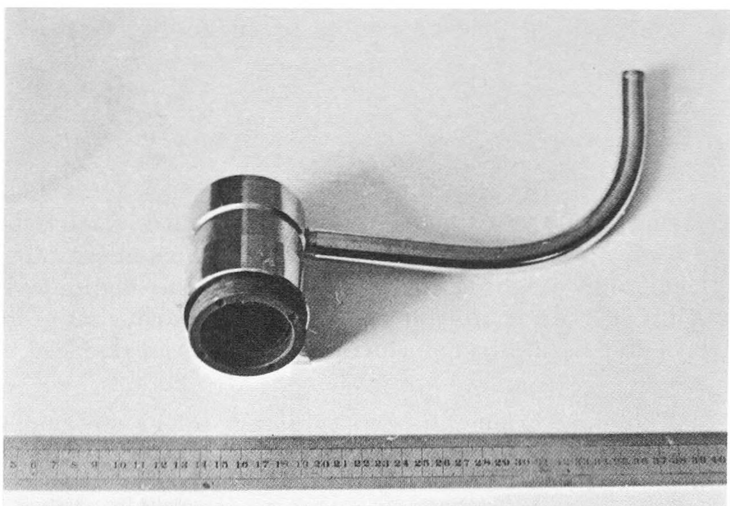


FIG. 5. — Receiving element.

Pulse synchronization

The equipment used to synchronize the transmission of the echo-sounding pulses in our case is built up on two printed-circuit boards mounted in the space normally occupied by the automatic black-grey unit in the echosounder that we use for our hydrographic surveying, a modified Atlas type 470 sounder.

An On/Off switch for the automatic synchronizing equipment and an out-of-synchronization alarm lamp are provided on the front panel of the echosounder.

ACCURACY

The accuracy of the distance-keeping equipment depends on the correctness of the value used for the velocity of sound in water. For sounding we use a mean velocity in the vertical plane. For distance keeping signals, however, only the warmer surface water is used, and this gives a distance error of about only 1%.

A calibration potentiometer in the receiver eliminates the equipment's inherent small fixed error which is normally of less than 1 metre. The manufacturer states that the remaining error would amount to 2%. Our test measurements, however, have shown that this error is in fact much less.

It was five summers ago that we tested our first experimental distance-keeping equipment. Very few features found in the 1967 version remain in today's equipment. Thirty receivers will be in operational use by three survey groups this season, and all will have frequency synchronization. We are convinced that we shall at last be able to attain the measurement precision and clean fathograms we have sought for so long.