AUTOMATION IN HYDROGRAPHIC SURVEYS

DIGITAL INSTRUMENTS AND THEIR OPERATION ON BOARD THE FINNISH SURVEY VESSEL "TAUVO"

by Erkki MATTILA
National Board of Navigation of Finland

and Sakari PAJUNEN
Chief Engineer of the Computing Section
Maansähkö Co., Helsinki

The conditions affecting hydrographic surveys in Finland are in certain respects exceptional. The archipelago surrounding the coast, which is traversed by numerous traffic routes, is characterized by its narrowness, shallowness and a surprising number of reefs. The vessels carrying out the surveys in these areas are highly exposed to the danger of becoming grounded. This has affected the development of the survey ships. The open sea constitutes of course also a part of the area, in the survey of which the National Board of Navigation is interested. The surveys there are carried out in the generally accepted manner by separate, individually operating vessels. When examining the measuring conditions in the open sea it may be observed that the distances from the coast to the survey areas are relatively small even when sailing through the archipelago. The vessels can thus rely on the service centres in the ports along the coast, thus the storage space in the vessels is designed to enable them to leave their bases for a week or a little more at a time. As they can seek shelter in the archipelago overnight or in the case of storms, a crew organized on the basis of watch-keeping in two shifts is sufficient for the survey vessels. All these circumstances lead to the size of the vessels remaining small as long as they are sufficiently seaworthy. The survey vessel *Tauvo* (fig. 1), which was delivered in the summer of 1963, was built for the National Board of Navigation on these principles.

The main measurements of the vessel are : overall length 28.30 m; beam 6.70 m; draught 3.00 m and displacement 190 tons. The main propulsion engine delivers 380 hp. The propeller is a controllable pitch type hydraulically operated from the Captain's bridge, from which the number of revolutions of the main engine can also be regulated. The steering-gear is electro-hydraulic and may also be connected to the autopilot, which in its turn is connected to a gyrocompass. The provision of such propulsion and navigation equipment was found to be justified despite the small size of the vessel, as it was thus possible to facilitate the

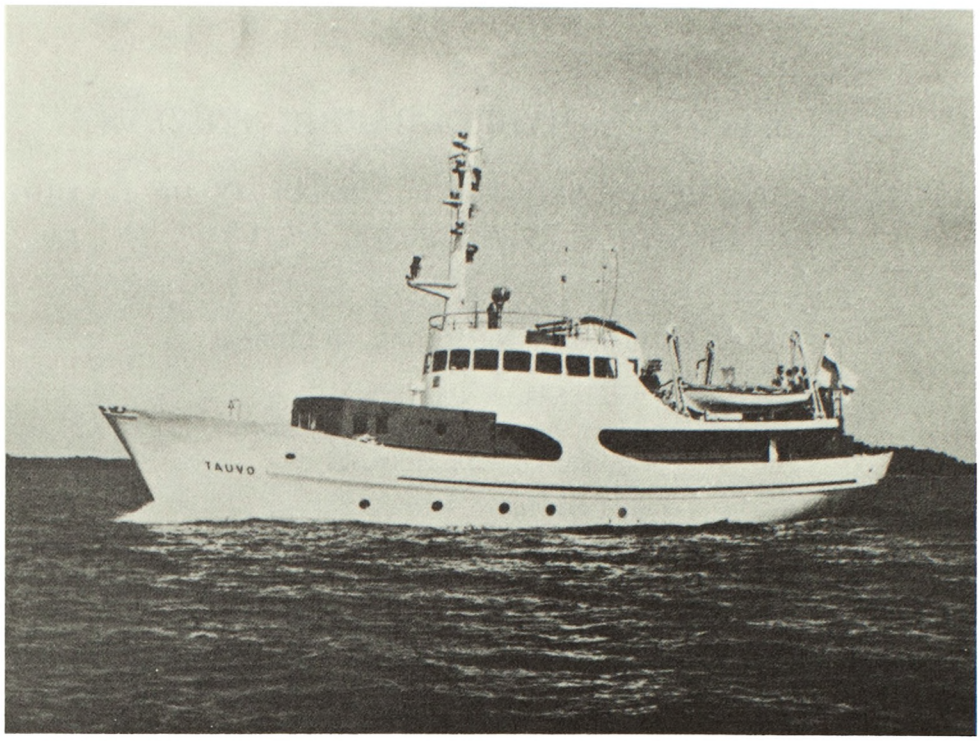
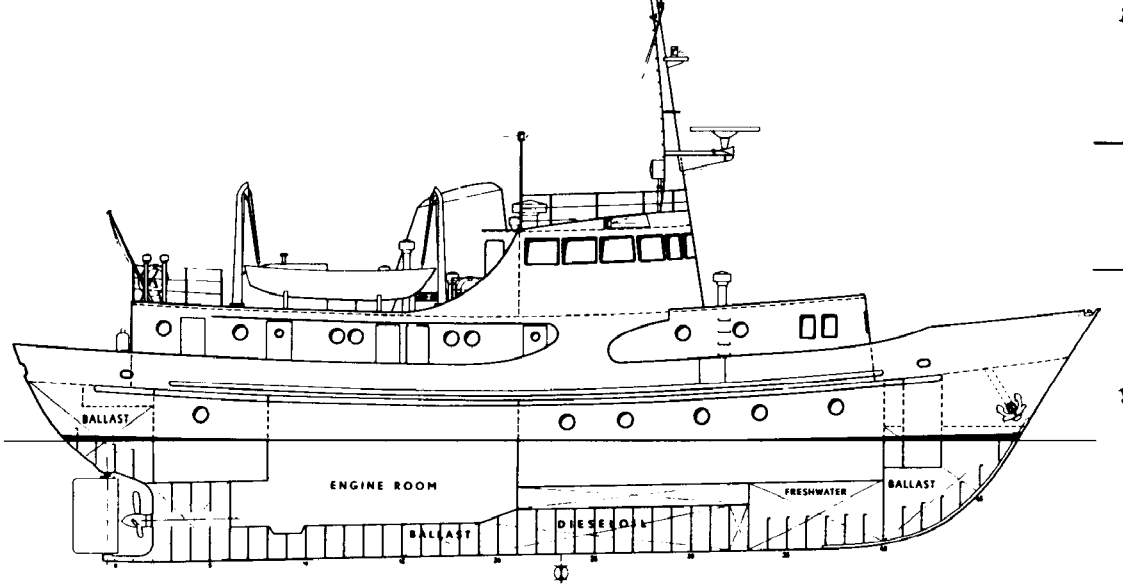


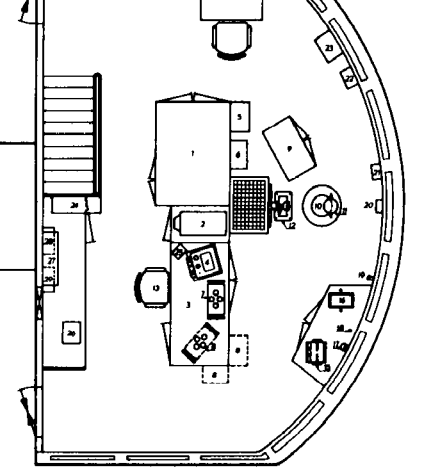
FIG. 1. — Survey ship *Tauvo*.

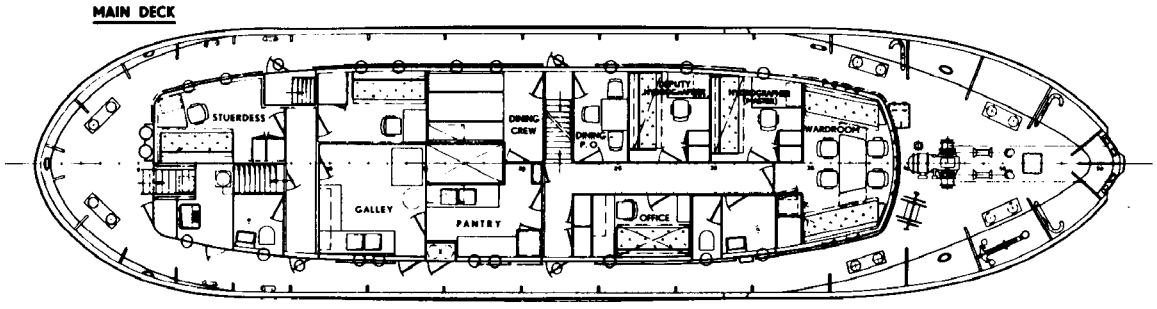
steering of the vessel when sounding in the open sea along the customary parallel sounding lines (fig. 2).

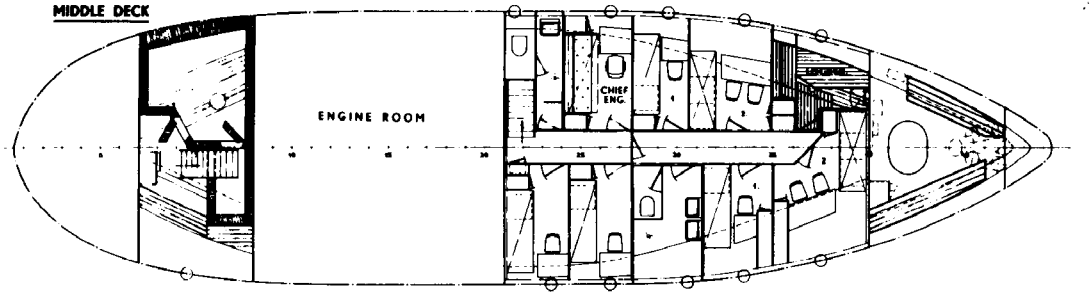
For actual depth recording the vessel is fitted with two Atlas-Monograph echo-sounders, one of which is used as reserve equipment. As several Decca-chains are in operation in the waters surrounding Finland — in the Gulf of Bothnia (No. 5 1/2), in the Bothnian Sea (No. 8) and in the Baltic (No. 4) — the normal position fixing of the vessel is based on the use of this system. For this purpose the vessel is equipped with a Decca receiver, Mark XII, and a survey receiver of the same mark will also be installed when the Decca Navigator Co. can deliver it. When using the Decca position fixing system it has been found useful to establish a monitor station on some island or on the coast in the survey area to control the vacillation of the net of the Decca hyperbolas. The monitor station reports the corrections of the Decca-chain to the vessels conducting the survey. Such observations are of course needed also for other measuring units than the *Tauvo*.

When carrying out the surveying, the vessels usually follow courses which are parallel with some of the hyperbolas of the Decca-chain, and the position of the vessel is fixed when intersecting hyperbolas are transversed. In order to follow some known hyperbola a left/right indicator is used, which can be pointed at the desired lane, or at a part of it, and which immediately indicates if the vessel deviates from the chosen lane. The transversing of intersecting hyperbolas is established from the decometer, and a note is made on the echogram and on the plotting sheet









1. Chart desk
2. Radar display unit
3. Desk for hydrographer
4. Echo sounder
5. Decca Navigator Mark XII, receiver unit
6. " " power unit
7. " " decometer
8. " " survey receiver
9. Decca track plotter and left/right indicator
10. Gyrocompass, Plath
11. Projector for magnetic compass
12. Wheel
13. High chair for hydrographer
14. Locker for signal flags and reserve desk
15. Regulating levers for screw and main engine
16. Engine room telegraph (in reserve)
17. Tachometer
18. Button for fog signal
19. Speaking-tube to engine room
20. Steering indicator
21. Switchbox for Arkas auto-pilot
22. SAL-log
23. Switchbox for gyrocompass
24. Electronic calculator connected with echo sounder
25. Code switch for electronic calculator
26. Device for punching of tape
27. VHF-radiotelephone
28. HF "
29. Two radiocommunication receivers

SURVEYING SHIP "TAUVO"

FIG. 2

on which the hyperbolas have been drawn. This is, however, a method used on *Tauvo* infrequently and is mainly applied as a reserve method in position fixing. The fact is that the gear may be switched to operate completely automatically, so that the only remaining task of the hydrographer, who has the watch, is to navigate the vessel along the chosen hyperbola and, naturally, to watch the working of the equipment. When operating automatically the equipment records the moments when the hyperbolas are transversed on punch tape and numbers them, and it also punches the depth measurements obtained from the echo sounder on the same tape. It has thus been possible to reduce the watch crew to the smallest possible number. Only a hydrographer and a helmsman are needed. A more detailed description of the automatic equipment is given below.

The survey vessel *Tauvo* has been built especially for echo sounding by area in open sea. This means in Finnish waters usually the measurement of depths from 10 to 200 metres. The bottom return gives there an echo that is at least 3dB over the noise level. In these conditions wrong signals can be filtered by electric means from the bottom echo at a probability exceeding 99.8 %. Where the bottom is soft mud and the depths vary very fast, the number of errors may increase if the gain adjustment of the sounding receiver is not carefully tuned.

For recording of the results on punched tape, an electronic calculator has been constructed. This works in parallel with an echo sounder. Briefly, it operates in the following manner :

A generator produces pulses with a frequency between 7 100 ... 7 400 c/s, depending on the sound velocity in the water in the prevailing conditions. For counting, a frequency will be chosen that gives one count at each 10 cm of the depth. The sounder output opens a gate from the generator to the counter and the echo closes this gate. Subsequent to this cycle the content of the counter corresponds in digital form with the result of the measurement. This can be coded and punched on tape by means of simple technical methods.

However, it is not possible and not necessary to write all measured depths on the primary depth chart. The scale of the charts is 1/40 000 or rather 1/20 000, when, however, sufficient space for all recordings is not available. On the other hand, it would be important to fix the position of each recorded sounding with the accuracy required, this time ± 10 metres. The cruising speed of the *Tauvo* is 10 knots and the repetition ratio of the used sounder is 4 c/s. This means that each 8th sounding must be recorded with a position mark.

Because the measurements are made to control safety conditions in waterways, it is most important to know the most shallow draughts. Therefore, the smallest recording of 8 sequential soundings is picked up on tape by means of the calculator (fig. 3). It is possible to record the maximum, too, but to do this, another counter provided with comparing circuits is required. Each punched depth gets a sequential number on the recording tape in order to provide the means to fix the positions. These numbers can be manually applied, or, for instance, automatically by means of a decometer.

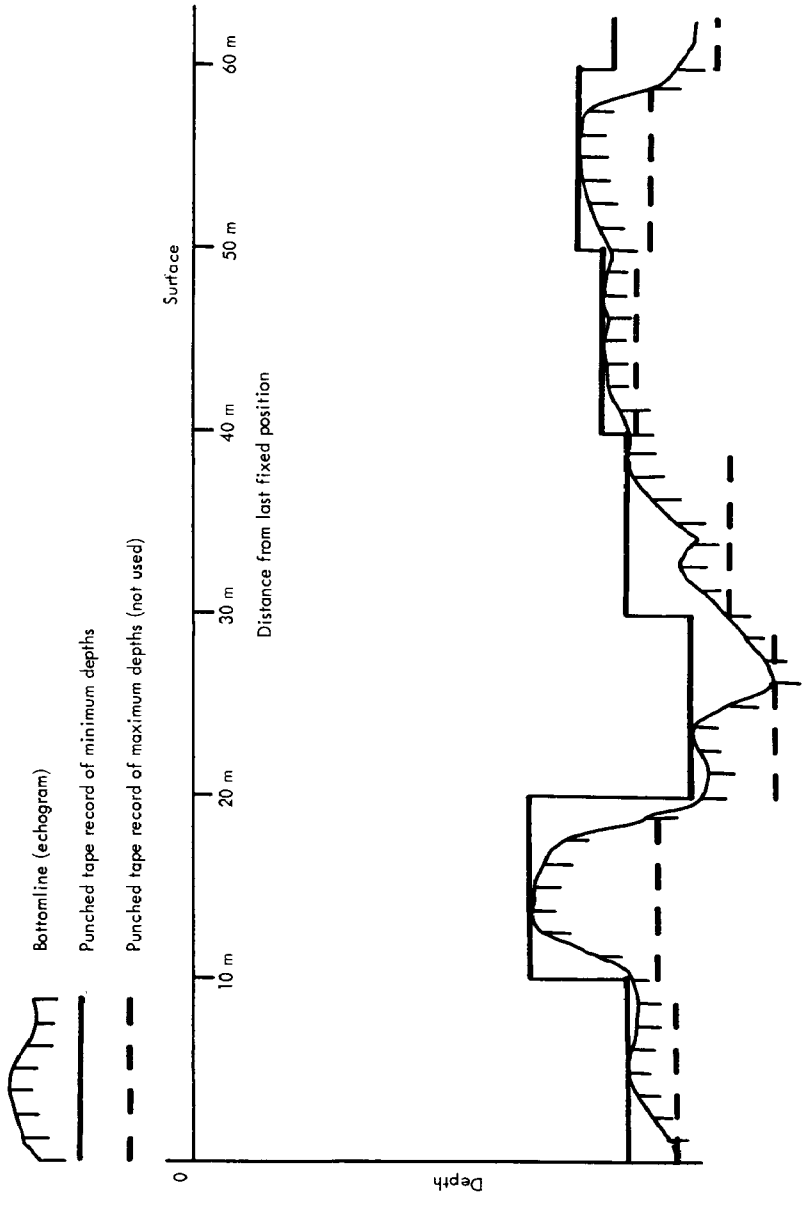


FIG. 3. — Example of depth records on board the *Tauvo*.

Eventual erratic recordings can be separated in two ways :

1) If all 8 sequential echoes are missed, a recording of overflow will be punched on the tape.
2) When processing in a computer, this compiles a separate deviation list recording all depths which point at any discontinuity of the bottom profile.

Eight sequential echoes can be lost only when the recording has been made in too stormy or otherwise unsuitable conditions, or when the sounder has been improperly adjusted.

Visual inspection of the echogram will reveal whether errors occur, or, for instance, a wreck or boulder interferes.

Data concerning positions can be separately punched by hand on another tape, again in numerical sequence. This tape and the one recorded with the depths comprise feed data for a computer. Computer programs have been developed where the whole procedure to produce primary depth charts can be automatically carried out in connection with a suitable coordinatograph.

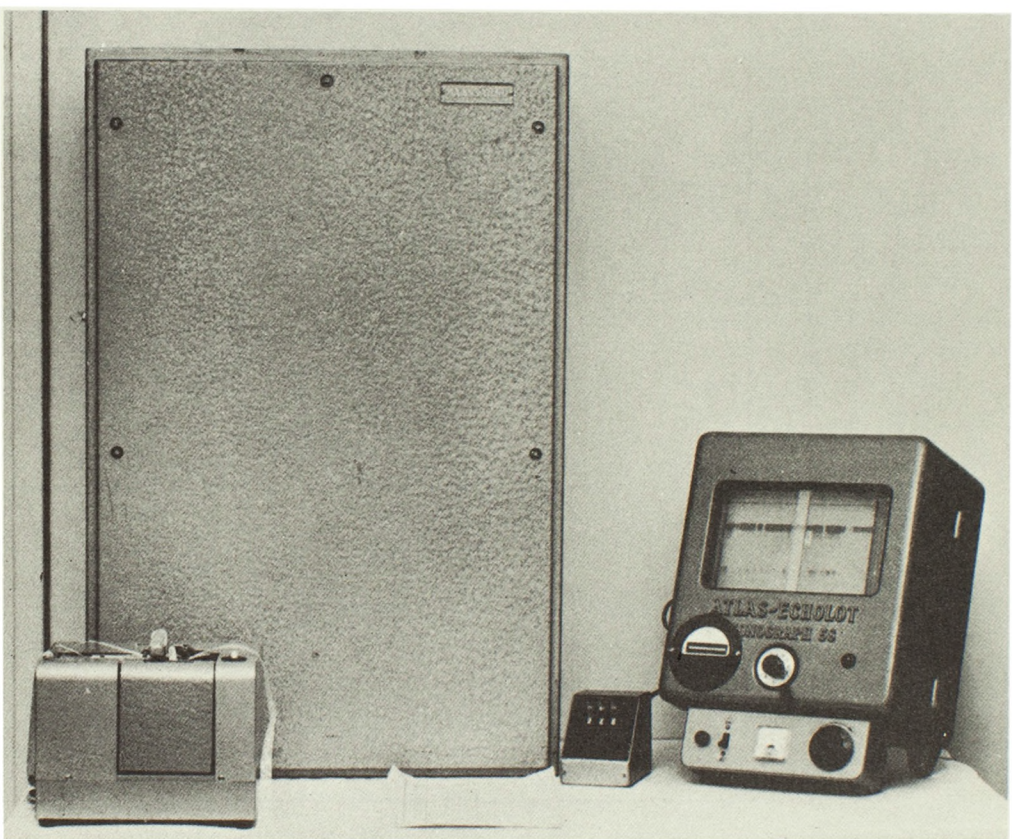


FIG. 4. — The electronic computer, complete with Atlas-Monograph.

The noise level at depths smaller than 5 ... 10 metres and a soft mud bottom with a great difference in depths can partly cause incorrect recordings, but test soundings have established that it is possible to save

up to 90 % of the manual routine work of reading the echograms and of drawing the primary charts.

On the *Tauvo*, the calculator has been built of solid state components and the moving contact of the few necessary mechanical relays is immersed in protective gas. The estimated life-time of its parts is considered to be more than 10^8 connections. The whole system is installed in a box of steel plate, having the dimensions $90 \times 60 \times 20$ cm (fig. 4). The tape punch box can be put away in any desired place. The total weight of the calculator is about 50 kg, and its power consumption does not exceed 250 watts.