Proceedings of The Institute of Acoustics

A SCAN CONVERTER FOR A SECTOR SCAN SONAR

Quarmby D.J., Duck G.M., Goodson A.D.

Department of Electronic & Electrical Engineering,
Loughborough University of Technology.

Background

Progress in digital memory technology over the past ten years has been remarkably swift. One result of this has been the marked reduction in price of graphical display systems based on standard television raster scans refreshed from a digital frame store. The paper describes an exploitation of these advances tailored specifically to 300 KHz sector-scanning sonar, (ref.1).

The authors had two objectives in mind when embarking upon this project. The first, short term objective concerned simply an alternative, and in many ways which will be stated, an improved technique for the display and recording of information from the sector scanner. A second, longer term objective was to provide a convenient tool for computer processing of the information, and to apply this tool in a variety of areas.

To date, three equipments have been built - a prototype and two sets to a better standard of construction built for two users of 300 KHz sector scanners. These are being used and have provided valuable experience in various sea trials in which recordings were made both on video-tape and on digital cassettes for computer processing off-line.

The paper describes the design and construction of the equipment; trial results and comparison of the display and recording with currently used techniques; and concludes with a summary of work in progress both on computer processing algorithms and on further hardware developments.

Design Overview

Diagram 1 shows, in block form, the general organisation of the equipment. It is specific to the 300 KHz sector scanner, which has a line rate of 10 KHz and frame rate of 2 Hz or 4 Hz. The equipment is synchronous i.e. all timing is derived from a single high-frequency clock source. This makes for a straightforward design procedure, but leads to some problems of synchronisation with the sector scanner. A simple and robust solution to this problem has been to supply, from the scan converter, a 1.2 MHz master timing signal to the sector-scanner in place of its normal internal clock. The signals required from the scanner are the video, and sync pulses for line and frame.

With any display of data from this sector-scanner there is the problem of resolving the large number of lines per frame (5000 at 2 Hz frame rate). Rather fewer than 625 lines can be displayed on a normal TV screen, requiring amalgamation of up to 8 sonar lines to produce 1 TV line in order to display the full range. An alternative display mode is needed to show a selected range window at the full resolution of 1 TV line to 1 sonar line. An input module capable of line integration or range windowing is used. The integration is done digitally using an adder and accumulating line buffer.

The store itself is organised on a 16-bit data bus. This is convenient for computer access, and the packing of picture points into a 16-bit word places less stringent speed requirements on the store.

The picture points are stored in 4-bit form. The availability of 16 grey levels is certainly adequate for most display purposes and is well matched with the dynamic range of monochrome monitors. It may well be that for computational purposes 6-bit resolution will be needed, and work currently in progress has allowed for this possibility. The store size allows for 625 lines, but only 75 points per line. This number was selected to match the 75-element arrays normally used, though it may well be that if more points were stored a subjective display improvement would be achieved. With still further reductions in memory prices it should be economically feasible to increase this number in the future.

The aspect ratio of the display was the subject of some experimentation. The display of a sector in a rectangular form can never give an accurate picture, but most operators have become accustomed to it. At full range, in order to present an acceptable picture it seems best to use a tall, thin display, using perhaps 1/3 of the rectangular TV screen. However, when using the range window, at full resolution, to preserve approximately the same aspect ratio the display width should be fully expanded. The equipment provides the operator with a choice of these two widths when in the 'expand' mode. There are two advantages to using the "tall, thin" display. One is that the limited bandwidth of the TV monitors/recorders automatically filters out the steps caused by spatial quantisation of the stored signal. The second is that a large area of blank screen is available for the presentation of logging information in alphanumeric form. Advantage has been taken of this.

In summary, the design centres on interleaved accesses to the main store by three modules - the input electronics (involving line integration) - the output electronics (involving buffering to produce a narrow picture) - and a computing element, a microprocessor. Other than the ADC and DAC electronics the system is all digital, and all timing is controlled by one master oscillator.

Construction

Diagram 2 shows the general layout of the equipment. It is based on standard 19" card cages arranged in 3 layers each 5U high and follows a modular scheme where possible. The top layer comprises a 9" monochrome TV monitor, and the system control module. The controls allow the choice of full range or expanded display. The choice of window position for the expanded display is made using a spinwheel control, which is rotary, yet totally digital in concept, based on a pair of simple on/off photoelectric sensors. Fast end-to-end spins or controlled incremented changes are equally simple. The window range is indicated on a LED display, and can also be displayed on the TV screen. It is normally frozen to avoid any effects from random motion of the spinwheel. A 'picture freeze' switch is provided to cut off new inputs to the store. This is a useful state to hold to examine particular pictures and is essential for the storing of digitised frames. The TV screen bears a time indication (either elapsed or actual time) and an identification number. These are set from the control panel. Remote start/stop for the video tape recorder are also provided on the panel, together with recording and replay electronics and controls for a sound track, if required. The VTR (if required) is normally housed in the bottom 5U frame.

The main electronics is on 5U cards in the centre frame. The picture store requires 3 cards, each of 8K bytes, using static RAM. These are printed circuits, as are the analogue input and TV output cards which contain the ADC and DAC respectively. There are 6 other cards which are all wire-wrapped - a reliable construction technique which is more suitable for development electronics, and made easily repeatable by the use of numerically-controlled semi-automatic wrapping. Although the project has been and is continuously developing, it has been thoroughly documented using professionally drawn circuits at each stage, a process encouraged by the need to produce control tapes for the N.C. wirewrapping machinery. The six cards perform the functions of:-

a) Master timing generations

b) Line integration (on input)

c) Packing and unpacking of data for store access

d) Control of memory address bus

e) Generation of TV sync pulses

f) Compression of video for the narrow display

The backplane is printed circuit and almost throughout uses parallel connections, so that boards can be plugged in anywhere.

The power supply is a lightweight switching unit for the main +5V requirements.

An additional wire-wrap card has been developed to produce the alpha-numeric display on the TV screen. This is microprocessor driven, and can pick up information from external sources relating to ship position and heading, array positioning, and any other information required for logging purposes.

Microprocessor access to the picture store was included from the outset in the prototype system, but a card has been added to the re-engineered versions only recently in order to permit digital cassette recording of frozen pictures. Various microprocessors have been used, but a 16-bit one is most suitable. The Texas 9900 is incorporated in the prototype, with a serial interface to a terminal for programming and control purposes.

Comparison with Current Display/Recording Techniques

The most widely used technique for sector scan display is the electrostatic tube, using a fairly long persistence phosphor. Compared with this technique, the scan converter provides the following advantages:-

a) the refresh rate is fast enough to give a flicker-free appearance

b) the display is bright enough for viewing without the need for darkened conditions

c) the picture can be frozen at any time

Recording is conventionally on an instrumentation tape recorder or by filming of the display. Compared with this the video tape recorder allows additional logging information to be added easily both in pictures and sound form.

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Equipment cost is of crucial importance. Because of the fairly complex electronics the scan converter is expensive for a single display. TV monitors are however much cheaper than the electrostatic displays, and so multiple display stations are easily produced - even at remote situations such as on the ship's bridges where it has proved popular. Replay at remote location is eased by the use of a widely available recording medium, and the video-tape recorders themselves are certainly a good deal cheaper.

These factors may be enough to see this type of display become the standard, but the potential for computer processing on the picture is probably the most important advantage.

Computer Processing - Some Application Areas

Most areas in which sector scanners have been applied offer examples of processing in which a computer can be usefully used. The first one we have considered is sea-bed profiling which is of interest to a variety of users. In particular the construction industries in the North Sea and in the coastal defence work in Holland are using sector scanners to examine the sea bed. There may also be significant improvements in hydrographic surveying using a succession of sideways-looking vertical sections to build up a 3-D seabed map (Diagram 3). Such a technique would complement the rather more qualitative information from a sidescan sonar set.

The majority of our digital recordings to date have concentrated on vertical scans and subsequently various stages of computer processing have been carried out to estimate the seabed line. These stages have included noise reduction by eliminating isolated, low value echoes; smoothing to improve continuity of strong scatterers, including the seabed; the identification of connected regions, and skeletonisation of those regions. The seabed at this stage will most likely be represented by a number of lines, with a few gaps caused perhaps by 'shadow' regions. There are other lines too, the main ones being the result of ambiguities from main beams outside the sector of sound 'illumination'. We hope to identify these ambiguities by observing position and gradient continuity at opposite edges of the sector (see Diagram 4), and also to be able to estimate gaps in the main line of the seabed. The resultant profile will then require a geometric transformation before being displayed or, more likely, plotted on an

X-Y pen plotter.

Another relatively simple application of computer processing is the identification of transponder echoes and tracking of a transponder to provide its position without much effort on the part of the scanner operator. This might involve an initial identification by the operator, perhaps using cross-wires generated by the computer and inserted into the display store, then a tracking operation to search for the strongest echo in a region close to the previous known position. This technique could be extended to observe and record the direction code produced by the fisheries laboratories "compass tag". Such operations are difficult to perform in special purpose hardware, yet represent trivial software problems.

Hardware Work in Progress

Work on presentation of the images in colour is also reported at this meeting (ref.2). These developments might be useful in highlighting the line of the seabed, or the position of a transponder, in a contrasting colour.

It is intended to link, or perhaps amalgamate into one the microprocessors responsible for alphanumeric display and for picture processing. Thus, it would be possible, for example to record on video-tape the exact position of a transponder, performing co-ordinate transformation and calculations allowing for array positioning (and perhaps ships positioning and heading) within the microprocessor.

A major development is in progress of a very fast processor, based on bit-slice technology, to allow some of the algorithms discussed to be performed in real-time, resulting in further display improvement. This hardware is completely designed and partly constructed, and we hope to describe its performance in the near future.

References

1. Holley, Mitson & Pratt, "Developments in Sector Scanning Sonar", Conference on Instrumentation in Oceanography, Bangor, September 1975.

2. Griffiths & Rodriguez Moreno, "A Colour Monitor for the Scan Converter", this meeting.

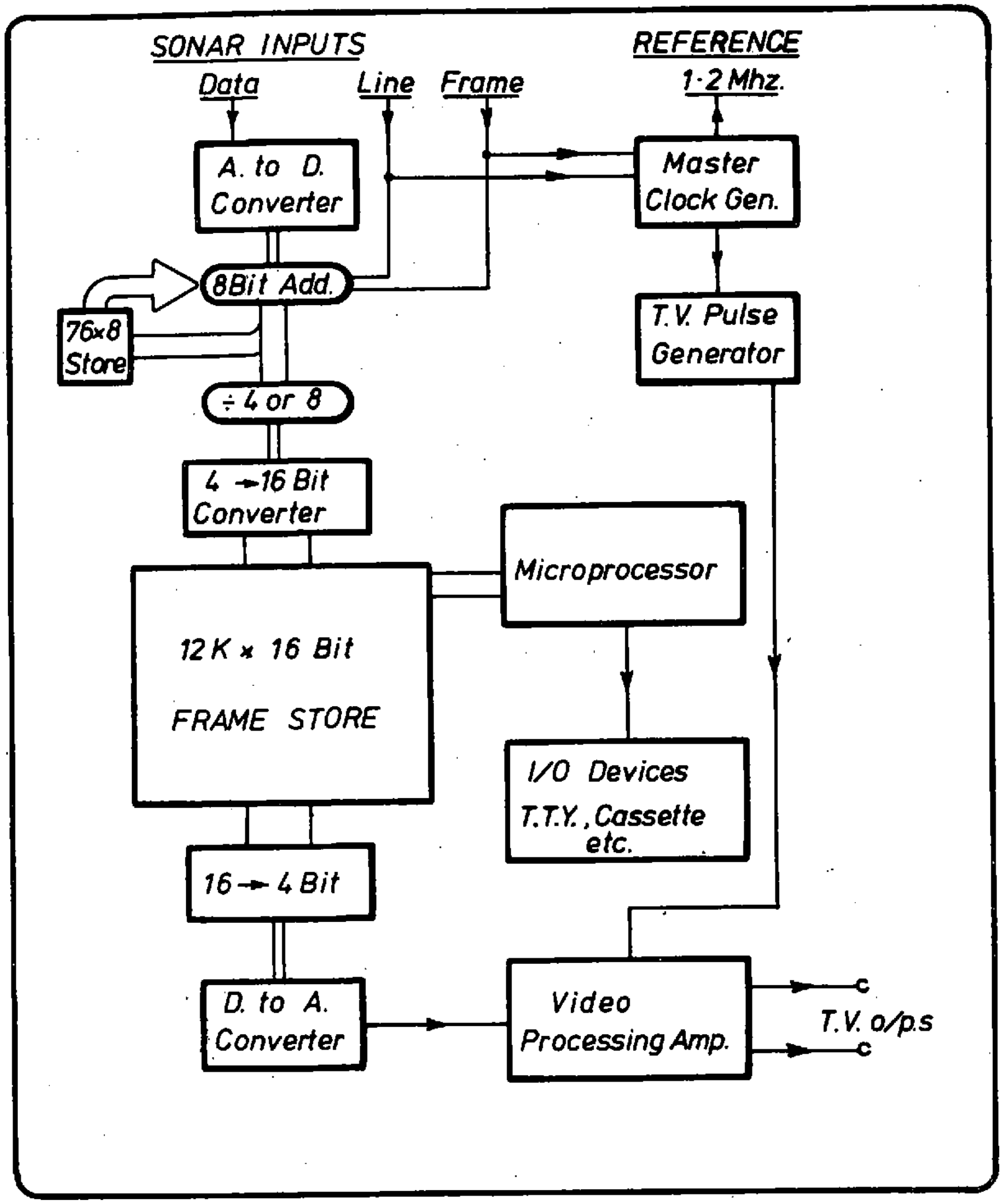

SONAR INPUTS
Data
Line
Frame
REFERENCE
1·2 Mhz.
A. to D. Converter
Master Clock Gen.
8Bit Add.
76x8 Store
T.V. Pulse Generator
÷ 4 or 8
4 → 16 Bit Converter
Microprocessor
12 K x 16 Bit FRAME STORE
I/O Devices T.T.Y., Cassette etc.
16 → 4 Bit
D. to A. Converter
Video Processing Amp.
T.V. o/p.s

FIG 1

SCANCONVERTER MK.1.

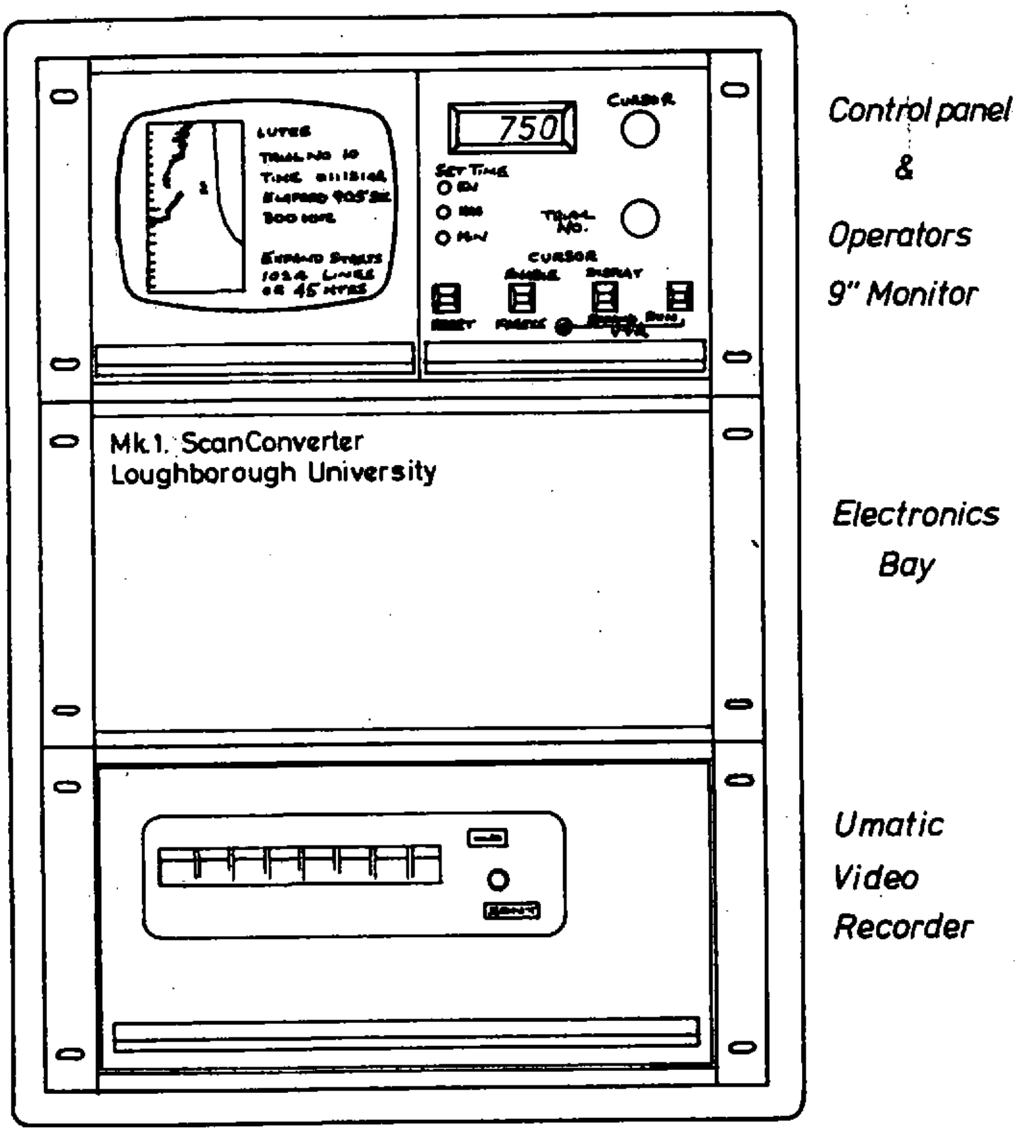
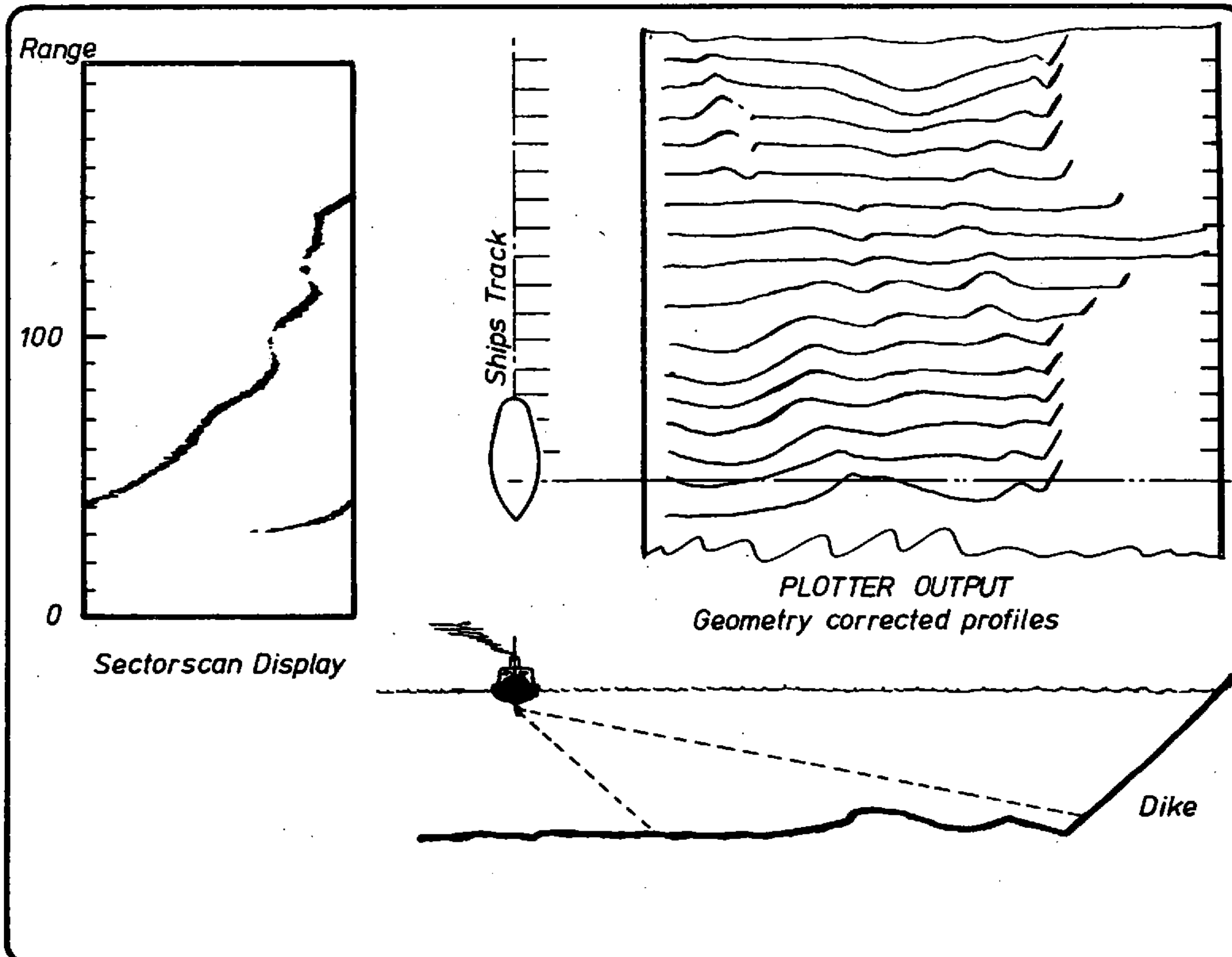


FIG 2



Range
100
0
Sectorscan Display
Ships Track
PLOTTER OUTPUT
Geometry corrected profiles
Dike

FIG 3

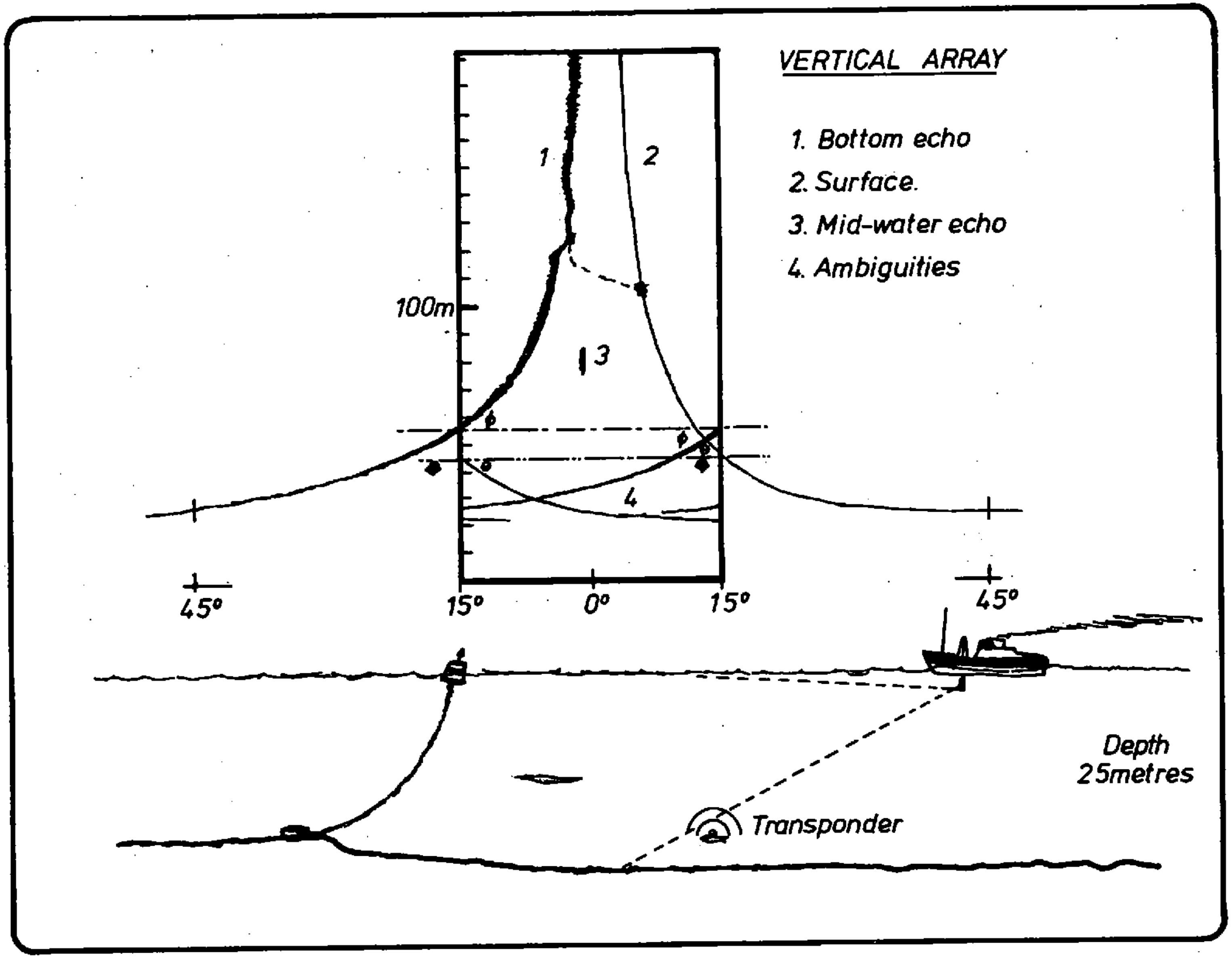

VERTICAL ARRAY
1. Bottom echo
2. Surface.
3. Mid-water echo
4. Ambiguities
100m
1
2
3
4
45°
15°
0°
15°
45°
Depth
25metres
Transponder

FIG 4