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THE USE OF A DIGITAL COMPUTER IN FISHERIES RESEARCH

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INTRODUCTION

During the planning stage of the new research vessel "G. O. Sars" some shipboard computers were already operational (Bowin et al.1967). The experience gained with these was so good that it became clear that a computer centred data system on the ship would offer great advantages. A need had also already been felt for automatic high speed sampling onboard our research ships (Midttun 1966). The needs were then analyzed and it was decided that a computerized data system should belong to the equipment on the ship. The planning of the system was placed with the Central Institute for Industrial Research, Oslo (Jahr 1968). As a result of this first planning it was decided to apply a medium size system which could perform data logging from a variety of instruments in real time on a time shearing basis. Some processing and data reduction should also be done in real time.

The same institute took also care of the further development of the system. This included choise of computer and nessecary peripherals, construction of electronic interface units and programming of the system (Jahr et al. 1970). The programming was, however, done in close cooperation with the Institute of Marine Research which had one scientist and one programmer employed with the project.

This paper will give a brief review of the system and describe some of the programming more in detail.

MATERIAL AND METHODS

The central part of the data system is a general purpose computer with 16 K core store, 16 bit word length and a memory cycle time of 1.7 microseconds. There are 16 priority interrupt levels. The peripherals that are connected to the computer are shown in Fig. 1 which gives a block diagram of the system. Instruments that are sampled in real time are also precented in the figure. Most of the instruments give analog signals and as seen in Fig. 1 they are sampled via a multiplexer and a 12 bit analog to digital converter (ADC). The sampling of the echo sounders required a fast analog to digital converter and therefore the system also includes a 10 bit ADC that makes possible sampling rates up to 50 kHz. Some instruments as for example the STD - system and the gyro compass give digital signals to the computer.

An important part of the system is a real time clock which gives interrupt to one of the priority interrupt levels once every second. Reading of the ships course and speed, Decca position, meteorological observations, and echo integrator values is monitored by the interrupts from the real time clock. Interrupts generated by the ships log govern the logging of sea surface observations and echo depth. The various real time programs included in the system are operated in a multi program mode and run on a time sharing basis monitored by the computers priority interrupt system. Programs for processing of the data have lower priority than the sampling activities, and they are initiated by software interrupts from the levels that are activated by hardware interrupts. Slow procedures like output of data, raw or processed on printer, punch cr plotter are placed on the lower interrupt levels. Here is also possibility for operating off-line programs, i. e. programs not permanently belonging to the datasystem, but are run in the computer temporarily.

Routine prin-out takes place every whole nautical mile on interrupt from the log and on clock interrupt every whole hour. A typical print-out is shown in Fig. 2.

Fig. 3 shows a listing of data derived from the STD system. This system provides signals for temperature, salinity and depth which are transferred from the under water unit as modulated frequencies. The frequencies are observed in the computer by means of binary counters and converted into temperature, salinity and depth. The data are stored on paper tape and usually sigma-t is computed from every fifth succession of observations and listed together with temperature, salinity and depth as illustrated in Fig. 3.

The real time programs for the logging of the echo integrators and the echo classifying program shall be described more in detail. The sampling of the echo integratoes gives an example of a relative simple data logging. The 6 integrator channels are as seen in Fig. 1 sampled through the 12 bit ADC on interrupt from the real time clock. The integrator values that in this way are read every second are integrated by the computer. The output is triggered by interrupt from the log and may be printed out with chosen intervals depending on the density of the survey grid. For very dense grids a print-out may be needed every nautical mile (Blindheim and Nakken 1971), but more often values are printed out every 5th nautical mile.

A far more complicated data handling is connected with the echo classifying. Then the echo sounder is sampled at a rate close to 50 KHz. Consequently the first management of the sample has to be accomplished in the course of a good 20 microseconds. This short time interval allows only a few program instructions to be executed so that this first data handling must be very brief. A flow chart of the sampling loops in the program is shown in Fig. 4.

The sampling is started by an interrupt from an interface unit between the echo sounder and the computer. On this unit it is possible to choose the depth and the gap of the depth-interval to be sampled. Interrupts are provided when the sound pulse passes the upper and lower limits of the interval. This interval is divided into slices of 8 metres thickness, and the computer keeps constantly record of what layers are "blank" and in which there are echoes. The start of a fish

(I.e. when a fish is just coming into the acoustic beam) requires that the associated slice was "blank" when the last ping was handled. This fish is then observed, ping after ping, untill the slice is blank again when the fish has mooved out of the beam.

Two conditions must be met before an echo can be taken as an echo from a single fish. Firstly the received pulse length, i. e. the duration of the echo, must be below a limit depending on the transmitted pulse, its length being measured at the 50% level of maximal amplitude. Secondly the amplitude of the signal that is received by the echo sounder must be above a surtain noise level or treshold and the maximal amplitude must be at least twice the treshold value. The reason for this is that the pulse length must be measured at an amplitude exceeding the noise level.

Depth differences within the sampling interval are calculated by the computer from counts of samples, i. e. an iteration counter in the sampling loops. This can be done since all the alternative loops possess the same number of instructions and therefore are aquivalent time consumers. The computer has plenty of time to carry out such calculations between the different pings.

The data that are stored after each ping when a single fish is being sampled is the maximum amplitude, the depth to he fish, the received pulse length and the integrated echo intensity. The sampling of the fish is finished when it passes out of the acoustic beam and the computer observes a "blank" slice again. The computer now performs some processing and prints out the observed data. An example of such a print-out is shown in Fig. 5. The upper part of this listing is initialisation data to the computer. After the intialisation the computer proceeds with printing out date and time, position and surface observations at the location. When this is done the echo classifying program is started and one line of data is printed out for each fish that is sampled. The printed data are: Depth to the fish in metres (DYP), the sector angle in degrees (FV), total integrated echo intensity from the single fish (C), maximal signal strength (MAX), pulse extention (DT) and signal strength in each echo that was received from the fish (DB). The sector angle is the angle within which the fish can be detected when the ship passes over it (Midttun and Nakken 1971). The different signal strength values are derived from the maximal amplitude in each ping and entered in terms of decibel. The pulse extention is the difference between the received and the transmitted pulse length.

RESULTS AND DISCUSSION

Generally speaking the data system has worked satisfactorily, but there were of course some difficulties at first. The computer has proved rasonably reliable though some trouble has been experienced with electronic errors and some minor components have had to be replaced. The logging of the data from the different instruments has worked quite perfectly as concerns the computer. However, some of the instruments have given erroneous data because the signals provided for the computer were out of calibration. This is particularly the case with the thermosalinograph which should observe temperature and salinity in the surface layer. To some degree also the barometer and the anemometer have offered similar difficulties.

Most of the peripherals have worked without any serious malfunction occurring. The only exception is the paper tape fast punches which have offered a lot of trouble. The two punches that originally were delivered with the system suffered from malfunction already when they were installed and it was not possible to bring them in working order. They were therefore replaced by punches of an other type. The experience with these has been better so far, but paper tape punches do not apear to be well suited for use at sea.

The sampling of the echo sounders has worked as planned and offered many advantages. The automatic reading of the echo integrators is more accurate and reliable than readings done by the opeartor. The fast sampling of the echo sounders provides much information that would be very difficult to get by other means. For example can the envelope curves of every single echo from a fish be sampled and precented on the drum plotter as illustrated in Fig. 6. It has also proved very useful to observe all echoes within a depth interval during a chosen number of pings. A frequency analysis of the observed signal strengths gives then good information of the size distribution of the observed targets.

Also the sampling of the STD-system is a great advantage. It is very convenient to get a listing of temperature, salinity and sigma-t simultaneous with the lowering of the probe. It is also an advantage to get the data directly on a computer compatible medium (paper tape). This enables automatic plotting of hydrographic sections and charts.

As a whole it must be concluded that the data system offers many advantages though some trouble has occurred. Its sampling speed and flexibility brings about possibilities for considerable improvements in several fields of the fishery research.

SUMMARY

A computer centered data logging system is placed on the new fishery research vessel "G.O. Sars".

The data system has devices for sampling of a variety of instruments (Fig. 1) and performs data reduction and processing in real time. The system is operated in a multi program mode and monitored by the computers priority interrupt system.

The echo sounders are sampled at a rate close to 50 KHz and a program for classification experiments on single fish echoes is included in the system.

The logging of the different instruments have been successful though some difficulties have been experienced with a few instruments providing erroneous data. Difficulties have also been offered by the paper tape punches. As a whole, however, the system has worked satisfactorily and provided several improvements.

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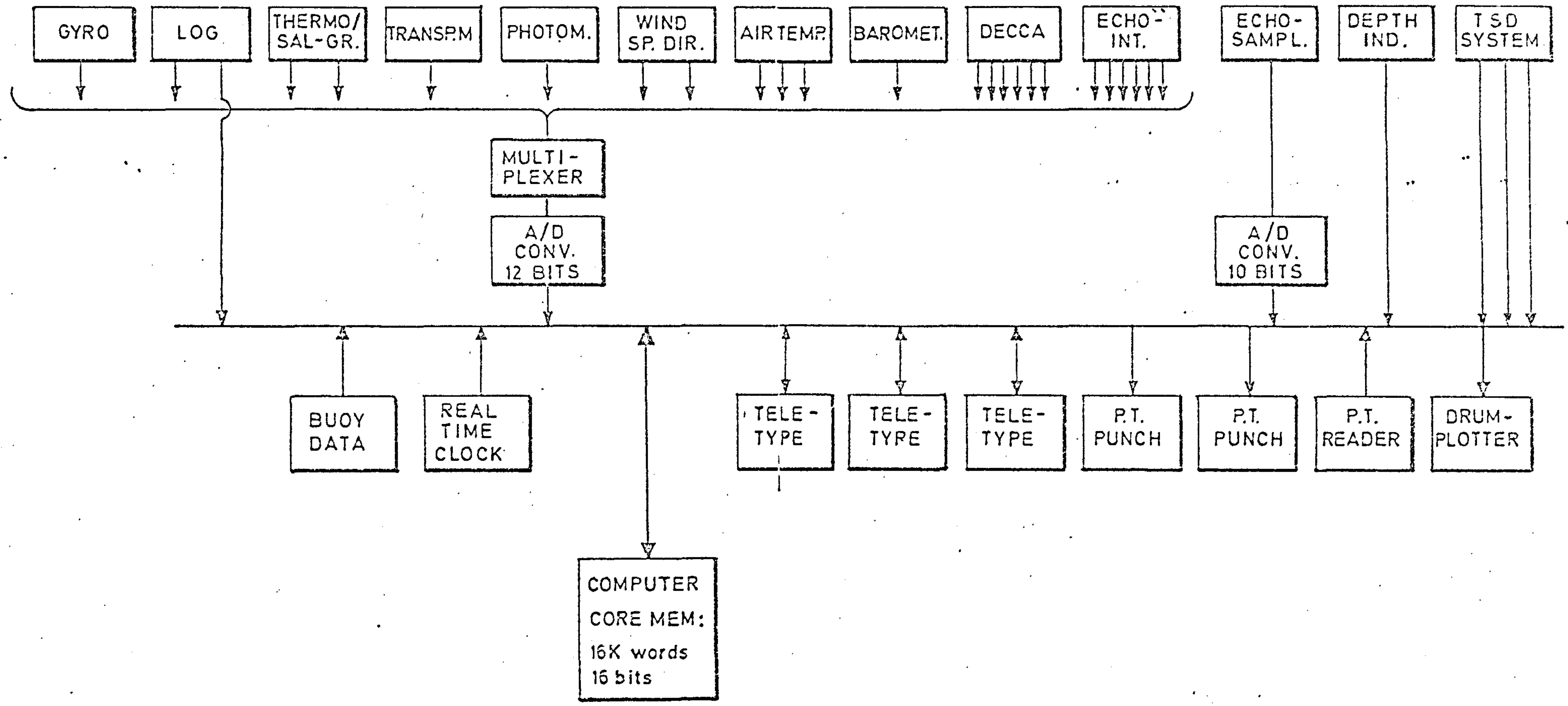

Figure 1. The shipboard computer system on R. V. "G. O. Sars".

TIME	LAT	LONG	LOG	SPD	STMP	SSAL	TRSP	DPT	CRS
06 02	58 54.7	3 37.3	16.0	10.3	8.3	33.4	14.0	236	147
06 07	58 53.9	3 38.2	17.0	10.4	8.3	33.4	14.1	247	147
06 13	58 53.1	3 39.1	18.0	10.6	8.3	33.4	14.1	257	147
06 19	58 52.2	3 40.1	19.0	10.3	8.3	33.4	14.0	263	147
06 25	58 51.4	3 41.0	20.0	10.5	8.3	33.4	14.0	270	148
06 31	58 50.5	3 41.9	21.0	10.2	8.3	33.4	14.2	281	148
06 41	58 53.3	3 39.8	22.0	5.9	8.3	33.4	14.2	281	331
06 51	58 53.3	3 37.9	23.0	6.0	8.3	33.4	14.1	249	266

TIME	LAT	LONG	LOG	PRES	AIRT	DEWP	LUXM	WF	WDIR
07 00	58 53.1	3 36.7	23.8	999.4	4.7	2.5	0.0	19	108

TIME	LAT	LONG	LOG	SPD	STMP	SSAL	TRSP	DPT	CRS
07 07	58 52.9	3 36.6	24.0	3.7	8.3	33.4	14.2	228	185
07 27	58 51.9	3 36.2	25.0	3.0	8.3	33.4	14.3	218	195
07 41	58 51.1	3 35.4	26.0	4.3	8.3	33.4	14.4	194	249

TIME	LAT	LONG	LOG	PRES	AIRT	DEWP	LUXM	WF	WDIR
08 00	58 51.7	3 35.1	26.9	1000.5	4.9	1.7	0.0	16	119

Figure 2. Routine print-out on interrupt from the real time clock or from the ships log.

ST NO 493
DATE 71 08 17

TIME	LAT	LONG	LOG	SPD	STMP	SSAL	TRSP	DPT	CRS
08 03	66 17.0	-24 47.0	484.0	11.3	0.0	0.0	55.8	107	120

DEPTH	TEMP.	SAL.	SIGMA-T
8	5.88	32.33	25.39
8	5.84	32.28	25.47
8	5.86	32.29	25.45
8	5.83	32.26	25.43
8	5.86	32.44	25.57
8	5.86	32.30	25.46
11	5.84	32.64	26.66
15	9.26	35.51	27.04
23	10.09	35.01	26.96
27	9.91	35.01	27.01
30	9.09	34.91	27.02
34	8.28	35.11	27.39
40	7.12	35.08	27.52
46	6.99	35.13	27.54
49	6.95	35.10	27.53
55	6.90	35.13	27.56
59	6.83	35.10	27.55
63	6.79	35.12	27.56
69	6.76	35.14	27.59
72	6.69	35.13	27.60
76	6.65	35.13	27.59
80	6.63	35.12	27.58
86	6.61	35.12	27.59
91	6.61	35.12	27.59
95	6.61	35.12	27.58
99	6.61	35.12	27.59

Figure 3. Listing of depth, temperature and salinity data from the STD-system. Sigma-t is calculated by the computer simultaneous with the lowering of the probe.

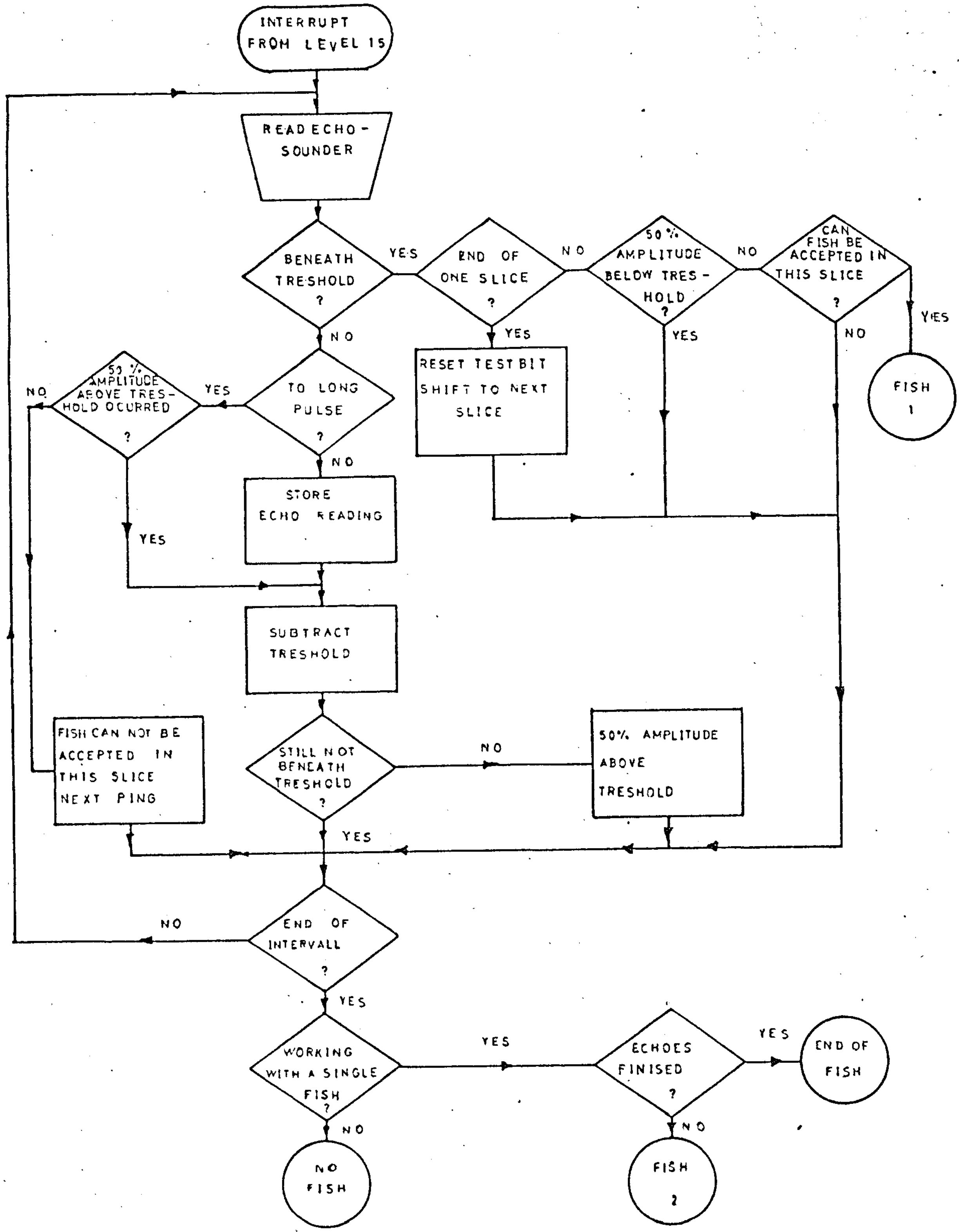

Figure 4. Flowchart illustrating the sampling loops in the echo classification program.

```
YES?
BG
GAIN -16
RATE 96
TOTAL 100
FRAME 4
INTEGR. 1
MAX DB -10

DATE 71 03 20
TIME    LAT         LONG     LOG    SPD   STMP  SSAL  TRSP  DPT  CRS
21 38  68  4.1   14 13.8   41.2    4.7   1.8   31.4  25.9  106  228
  68    5   0 -54  91 -56

 DYP  FV   C  MAX   DT   DB
  64   8 166 -27   93 -39-28-27-27-37
  59   2   3 -39   73 -39
  68   6  35 -32   91 -40-33-32-39
  64   2   0 -45   81 -45
  62   2   0 -43   89 -43
  60   7  26 -33   89 -38-33-35-41
  79   2   0 -43   24 -43
  71   6   9 -37  101 -41-45-37-43
  72   2   2 -40  122 -40
  71   2   0 -45  112 -45
  79   4   1 -39   10 -40-39-41
  68   2   2 -41  112 -41
  69   2   0 -45   97 -45
  63   6  51 -30   87 -34-30-34-38
  67   2   0 -43   85 -43
  63   5  12 -37   95 -39-37-40
  78   5  34 -32   97 -40-39-32-37
  78   5  28 -31   91 -41-39-31-40
  69   2   0 -43   97 -43
  72   7  65 -31   85 -41-34-31-32-35
  80   4   9 -37   89 -41-37-40
  76   3   2 -41   89 -41-43
  85   5  33 -33   91 -37-33-34-41
  76   8  41 -33   85 -41-36-33-33-37-45
  63   6  19 -34   91 -45-38-34-38
  82   5   7 -40   93 -41-40-41-43
  89   1   0 -45   53 -45
  89   5   3 -39   48 -39-45-43-45
  89   2   0 -45   73 -45
  63   5  19 -34   87 -40-34-36
```

Eff. 1/1   38 kHz   Transd. 3(1)

Figure 5. Print-out from the echo classification program.

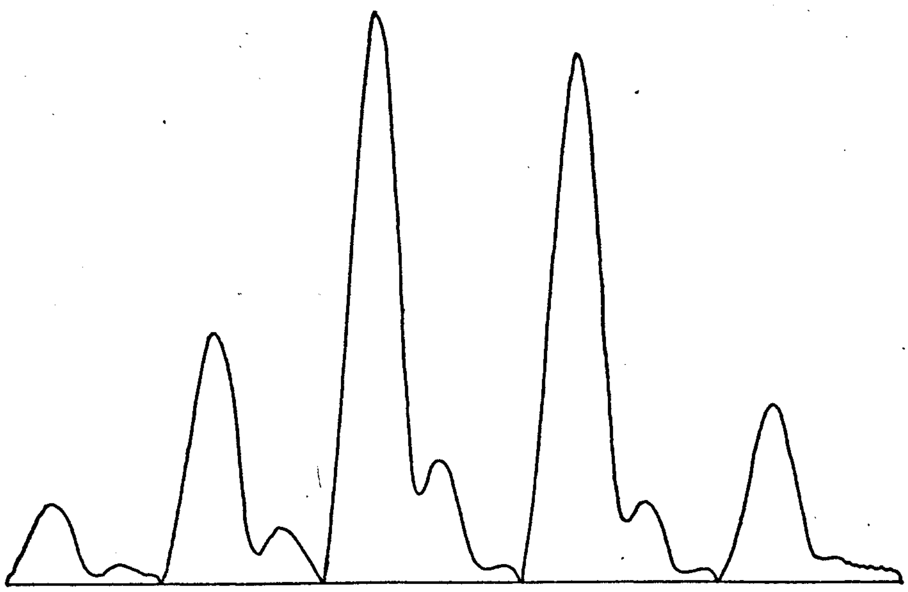

Figure 6. Plot of the envelope of 5 echoes from a fish as it passed through the acoustic beam. The echo sounder was here sampled at a high speed and the data were plotted on a drum plotter.