International Hydrographic Review, Monaco, LIII (2), July 1976

A NEW COMPUTER SURVEY SYSTEM

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INTRODUCTION

To cope with the increasing demand for hydrographic surveys as well as to improve the quality of survey results involving huge amounts of data, the best way seems to be to introduce an automated system into each process. This would further be effective in solving the problem of shortage of skilled surveyors now faced in this sector.

The system presented in this paper, which is still being evaluated, has been developed on the basis of the above considerations. The data are automatically acquired aboard a survey ship, while the capabilities of electronic computers and automatic drafters ashore are fully utilized for better efficiency and accuracy in processing survey data as well as in drafting smooth sheets.

Data of positions, soundings, etc., enter the data acquisition unit (data logger) through an interface from the respective sub-systems, and any necessary processing such as analog/digital conversion is automatically done before recording on cassette magnetic tape (CMT). For wider usage this logger is made portable, with minimal size, weight and power consumption; thus it can be installed aboard even a small survey craft. The unit records a set of data every second, and 4-hour continuous recording of data can be made by using two cassette tapes alternately.

The data processing unit ashore consists of a small-sized, 28-kiloword electronic computer together with a cassette tape recorder, a magnetic disk, a typewriter, a line printer, a CRT, and a large-sized drafter of flat-bed type. Its functions are: to check raw data acquired and to make necessary amendments, deletions or additions; to make corrections of various kinds, conversions and selections; to do automatic drafting, etc. In order to facilitate processing by the surveyor, input of orders can be made through the CRT at each processing step. Data thus processed are re-recorded on magnetic tapes and filed for re-processing as well as for supply to users at a later date.

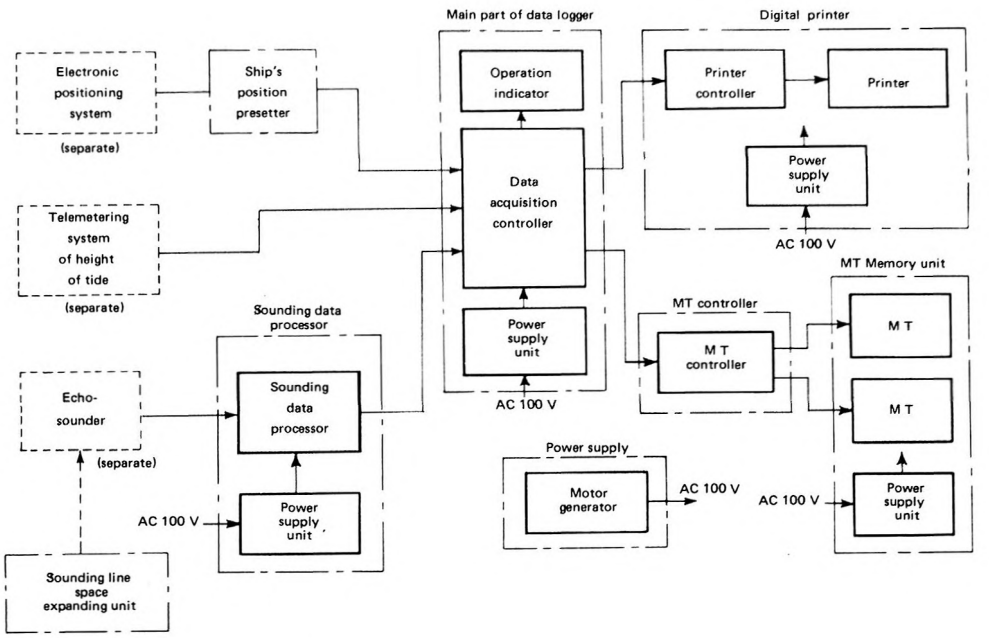

FIG. 1. — Block diagram of data logger for hydrographic survey.

FIG. 2. — Data logger.

DATA LOGGER

This unit, mounted in a small survey launch, performs on-line and real-time acquisition of data on a cassette magnetic tape; by linking the logger with the data processing unit ashore, computerization of every step of data processing can be made. Circuits for confirmation of data and for alarm are inserted at appropriate stages so that errors or omissions in data acquisition or among the data themselves are avoided or detected.

The unit consists of a data acquisition controller, a sounding data processor, a digital printer, a magnetic tape controller, a magnetic tape unit, and power supply. See figures 1 and 2. As shown in fig. 1, all data are passed through the interface unit and are further sent to the magnetic tape recorder through the tape controller. Time signals are sent from the clock circuit. Sounding data can be recorded as either : (a) the average *or* the least sounding value each second from each of the four channels separately; or (b) the average *or* the least sounding value from the pairs of channels on both sides of the survey launch separately.

Characteristics

(1) Input from electronic positioning system : once per second, 6 digits $\times$ 2 sets.

(2) Input from echo sounder : maximum 10 per second, 3 digits $\times$ 4 sets.

(3) Input from telemetering system for height of tide : once per minute, 3 digits.

(4) Duration of continuous data collection : maximum 4 hours.

(5) Magnetic tape used : compact cassette type.

(6) Power supply : AC 100 V $\pm$ 10 V, 50/60 Hz, 600 VA.

(7) Environmental conditions :
   (a) Temperature : + 5 °C to + 40 °C.
   (b) Humidity : 20% to 80%.
   (c) Vertical acceleration in operation : less than 1 G.
   (d) Vibration in operation : within 30 Hz.

Sounding data processor

In this unit, time intervals between echoes and transmissions input from a 4-channel echo sounder are measured using the clock pulse corresponding to the assumed velocity of sound of 1500 m/s. Corrections for draft are simultaneously made, and the result sent as sounding data to the main part of the data logger. Echo signals less than a given value are rejected by the preset time-gate, and those shoaler than the sea-bottom gradient as estimated by the surveyor are also rejected.

For checking of any malfunctioning, easy comparison can be made between the digital data and the analog record of the echo sounder.

DATA PROCESSING UNIT ASHORE

General

Considerations in selecting the hardware for the system, as well as in designing and evaluating the program for it, were :

(1) Among the data received, there may be unnecessary or faulty data included, or some necessary data excluded, which will make automatic drafting impossible. It is therefore necessary to provide a function to delete the former and insert the latter.

(2) At the final stage of extracting those data used for drafting and filing, it is necessary to use the judgement of the surveyor as well as the automatic data processing by computer program. The problem is in how to convey the judgement and instructions from the surveyor to the system.

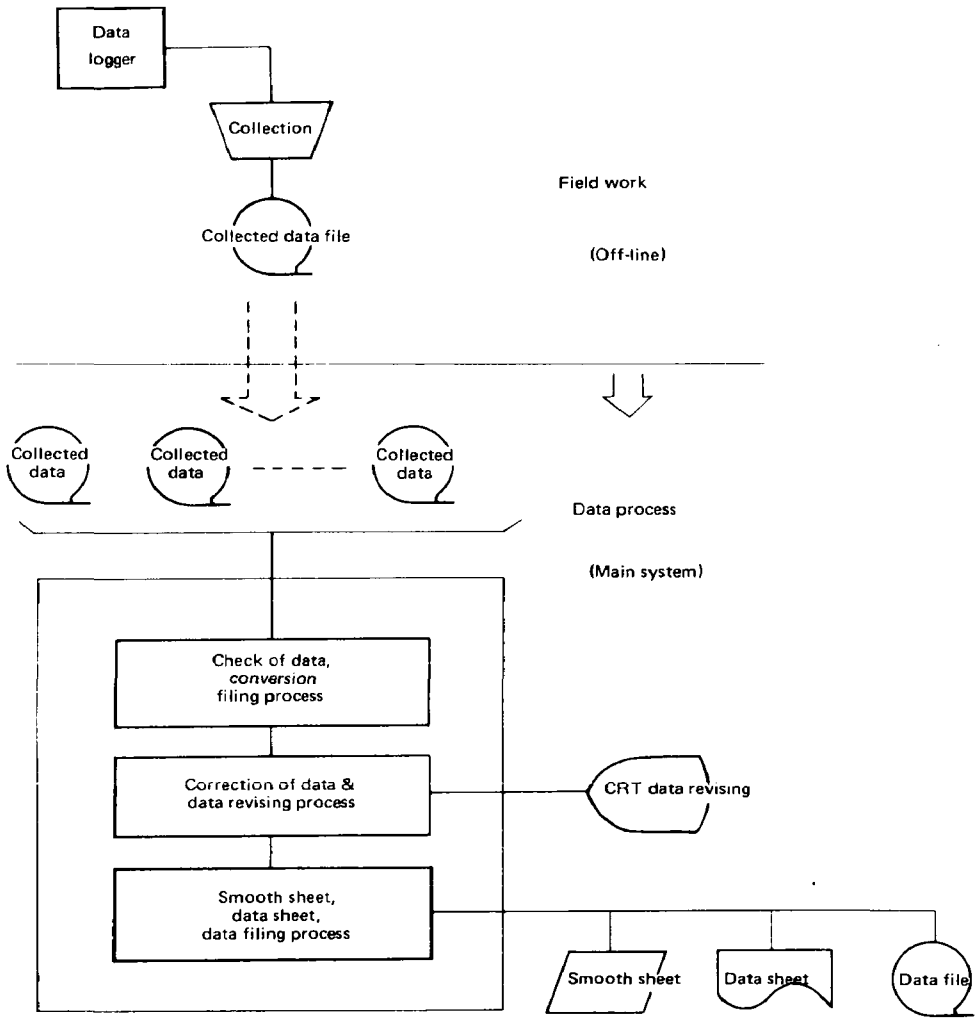

FIG. 3. — Outline of system.

Survey data received on cassette tape is checked, converted (in case of ship's position), corrected and revised (amendment and deletion) by CRT display, before the preparation of a smooth sheet of the survey area, with its data sheet and data file on cassette magnetic tape. Fig. 3 shows the outline of the system, and Table 1 lists its components.

TABLE 1

Instrument	Quantity	Remarks
OKITAC-4300 Type D Central Processing Unit (CPU)	1 set	Memory 28 K
Console Typewriter (CET)	1	132 strokes/line, 1 000 strokes/min. 8 unit ISO code
Drafter	1	Flat type
Magnetic disk unit (DISK)	1	2.5 Megawords for 2 disks
Display unit (CRT)	1	Dot type with light-pen
Cassette magnetic tape recorder (CMT)	1 set	With buffer
Line printer (LP)	1	132 strokes/line, 220 lines/min.
Paper tape reader (PTR)	1	30 000 strokes/min. 8 unit ISO code

Fig. 4 shows the block diagram, indicating the connection between various instruments; fig. 5 shows the appearance of the whole unit.

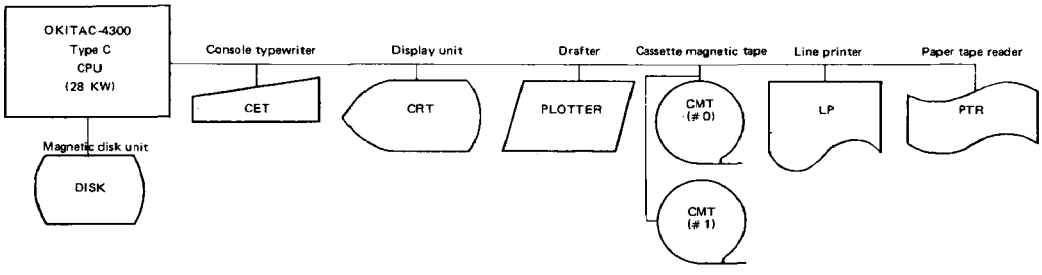

FIG. 4.

Processing at each step

The first step is to check the CMT data (time, ship's position, water depth, and height of tide), to convert data (ship's position), to correct data (ship's position and height of tide), and to file it on the magnetic disk (DISK) of the processing system. This step is called "Survey Data Filing".

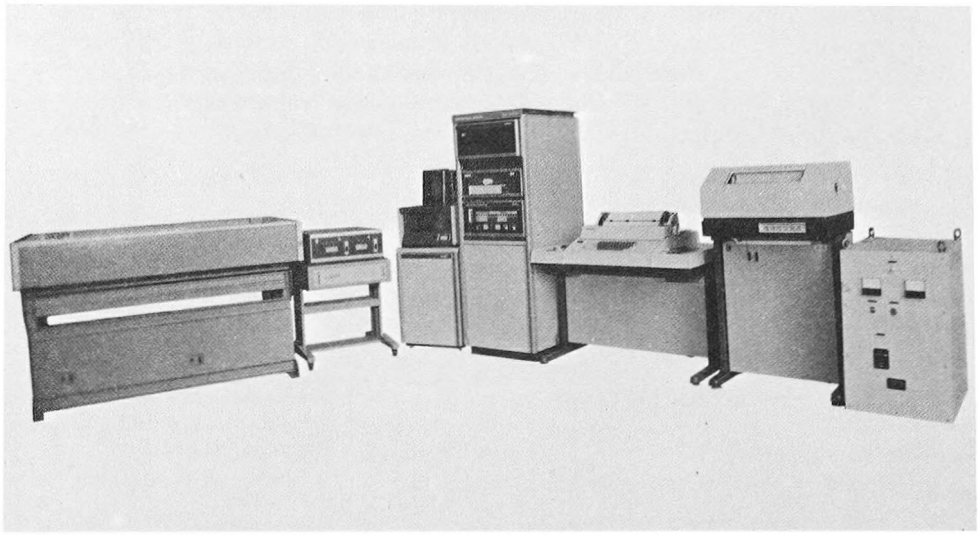

FIG. 5. — Data processing system.

Next, the data on DISK are extracted, amended, deleted or corrected, and a revised data file is prepared on the CMT again. This step is called "Survey Data Revising".

In the final step, a smooth sheet and a data list for the designated area, as well as a smooth sheet CMT data file, are prepared. This step is called "Smooth Sheet Preparation". These steps are explained below.

Survey Data Filing

Prior to processing, the following parameters are designated through the typewriter :

- Survey area.
- Zone of application of each Z_0.
- Zone of application of each tidal station.
- Method of position fixing.
- Draft of echo sounder transducers.
- Date of survey.
- Periods of useless data on the tape cassettes.
- Conditions for discriminating the quality of data of ship's position and height of tide.
- Conditions for interpolating data on ship's position and height of tide for the period when data are missing.
- Actual velocity of sound in sea water.

Using these parameters, the data on ship's position and height of tide are checked, and faulty data are deleted; a list of deleted data is prepared, as shown in fig. 6.

For any period in which both kinds of data are *not* recorded, data will automatically be inserted by interpolation if the instructed conditions are fulfilled, so that ship's position or height of tide are continued from data

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TIME (H/M/S)	ID	POSITION (Y)	(X)	DEPTH (CH1)	(CH2)	(CH3)	(CH4)	TIDE
16/32/ 0		0	0	198	204	208	199	0
16/32/ 1		0	0	199	206	208	199	0
16/32/ 2		0	0	199	206	209	198	0
16/32/ 3		0	0	199	207	205	198	0
16/32/ 4		0	0	199	205	205	198	0
16/32/ 5		0	0	197	202	209	198	0
16/32/ 6		0	0	198	203	207	198	0
16/32/ 7		0	0	198	207	207	199	0
16/32/ 8		0	0	198	203	209	199	0
16/32/ 9		0	0	199	202	208	199	0
16/32/10		0	0	198	207	205	198	0
16/32/11		0	0	199	206	206	198	0
16/32/12		0	0	197	204	209	198	0
16/32/13		0	0	198	203	207	198	0
16/32/14		0	0	199	206	206	198	0
16/32/15		0	0	198	206	205	199	0
16/32/16		0	0	198	206	206	198	0
16/32/17		0	0	199	207	206	198	0
16/32/18		0	0	199	205	206	199	0
16/32/19		0	0	198	206	206	198	0
16/32/20		0	0	199	205	207	199	0
16/32/21		0	0	198	203	208	198	0
16/32/22		0	0	198	206	205	198	0

FIG. 6. — Deleted data list.

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POSITION

	DATE (Y/M/D)	TIME (H/M/S)		TIME (H/M/S)
1	50/10/10	8/48/ 0	-	9/27/59

TIDE

	DATE (Y/M/D)	TIME (H/M/S)		TIME (H/M/S)
1	50/10/10	8/48/ 0	-	11/43/59
2	50/10/10	11/44/ 0	-	12/ 1/59
3	50/10/10	12/ 2/ 0	-	13/58/59

FIG. 7. — List of periods in which data are not recorded.

recorded before and after the blank period. In a case where this interpolation is impracticable, such a period is judged as one in which data are not recorded, and is noted on a list (fig. 7).

Ship's position data are converted into X-Y co-ordinate values after the necessary corrections. Checking is then automatically made of individual data, namely, if the difference between the moving average of differences of ship's positions within the last 10 seconds and the difference of an individual one exceeds the designated amount, an alarm is signalled. In the case of height of tide, if the difference from the preceding value exceeds a designated amount, an alarm is indicated. Fig. 8 shows an example of alarm data lists for position and height of tide.

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TIME (H/M/S)	ID	POSITION (Y)	(X)	DEPTH (CH1)	(CH2)	(CH3)	(CH4)	TIDE
10/ 7/22	*D	7053	2474	111	111	109	114	198
10/12/59	*D	6991	2448	107	107	106	107	196
10/28/ 5	*D	7541	2621	110	115	117	120	193
10/33/34	*D	7083	2457	108	108	107	107	192
10/38/36	*D	5023	2602	123	125	124	126	190
10/39/30	*D	6946	2436	105	107	106	107	190
11/ 2/ 0	*D	6265	2341	117	118	119	123	183
11/ 8/ 2	*D	6248	2313	118	119	118	107	181
11/ 8/ 5	*D	6362	2307	118	107	104	106	181
11/15/25	*D	6029	2218	114	120	110	109	178
11/17/ 9	*D	5742	2171	105	125	112	107	177
11/17/10	*D	5706	2168	108	115	108	109	177
11/23/22	*D	5405	2108	115	107	106	110	174
11/23/26	*D	5552	2118	108	111	124	109	174
11/23/31	*D	5739	2137	107	114	111	107	174
11/25/29	*D	5515	2095	109	112	122	108	173
11/25/30	*D	5475	2101	108	125	120	109	173
11/25/32	*D	5396	2101	110	109	106	110	173
11/31/43	*D	5369	2049	106	124	109	107	170
11/31/44	*D	5411	2049	106	109	107	107	170
11/33/51	*D	5221	1998	104	110	109	119	170
11/33/53	*D	5143	1995	105	110	120	119	170

FIG. 8. — Alarm data list.

In the case where some position and/or height of tide data are missing in the DISK file, data will be added using paper tapes if certain conditions are fulfilled. For example, if no tidal data are recorded on CMT because the tide telemetering system was not connected to the data logger, the height data are put in DISK at this step. Processing of added data for conversion of co-ordinates and corrections is now done, as well as smoothing of tidal data by the moving average method to eliminate short-term variations due to waves and swell.

Survey Data Revising

For checking sounding data quality, the allowable differences between sounding values obtained by all 4 beams, as well as between preceding and present sounding values from each beam, are designated in advance through the typewriter. Those data exceeding the allowable differences are automatically indicated by an alarm mark, and a list of such alarm data is prepared.

Then, considering the scale of the smooth sheet, sounding line spacing, sea bottom configuration and the survey ship's speed, the average interval for selecting soundings along sounding lines is designated through the typewriter. The minimum sounding value within the designated interval is found, and automatically marked (A). Data marked (A) are adopted for inclusion on the smooth sheet and track chart. It is also possible for a surveyor himself to select any other data for drafting the smooth sheet. The surveyor can call up on the CRT any of the survey data in DISK, and designate it by using a light-pen, after checking. Data thus selected are marked (B) or (D). (Fig. 9). This step will be repeated after the next step

of "Smooth Sheet Preparation", thus contributing to the perfect selection of sounding data. *It is this looping between the two steps that is the most important function of this new system.*

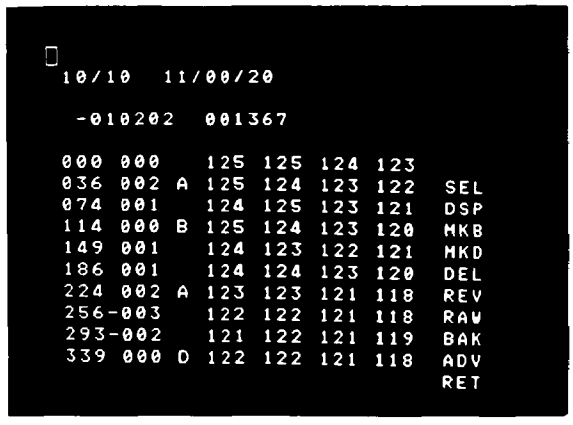

FIG. 9. — Display on CRT.

Explanation :

Line 1 : Month/Day Hour/Minute/Second
Line 2 : Y co-ordinate X co-ordinate
Table (Lines 3 to 11) :
Col. 1 : ΔY.
" 2 : ΔX.
" 3 : Mark : A (minimum sounding selected automatically), B (sounding selected manually), D (extraneous object).
" 4 to 7 : Soundings obtained by Channels 1 to 4, respectively.
" 8 : Function : SEL (select), DSP (display), MKB (mark B), MKD (Mark D), DEL (delete), REV (revise), RAW (raw data), BAK (shift time 10 seconds backward), ADV (advance time by 10 seconds), RET (return to designated date and time).

Preparation of Smooth Sheet

Data marked (A), (B) and (D) become the data adopted for preparation of the smooth sheet. Firstly, a track chart at the designated scale and limits is prepared; since it was possible to designate the date and time of measurement of the data adopted, drafting and examining of any part of the survey area can now be done during this processing step.

At the plotted positions, the time of measurement is marked. Fig. 10 shows an example of a track chart of a portion of the survey area (drafting time : 16.9 min). As seen from this chart, the sounding lines are parallel, straight lines, and the average interval is about 7 metres.

The smooth sheet prepared on the same scale (1:1000) is shown in fig. 11 (drafting time : 18.1 min). Generally speaking, overlapping of adjoining sounding figures is seen on this original automatically drafted sheet, due to computer selection of shallower soundings or to a narrower spacing of sounding lines. In such cases, the surveyor himself determines the soundings to be deleted, using the smooth sheet and the corresponding track chart. Then he returns to the preceding "Survey Data Revising" step, and by using a light-pen deletes the unnecessary ones on the CRT. The example shows a sheet on which this process has already been done.

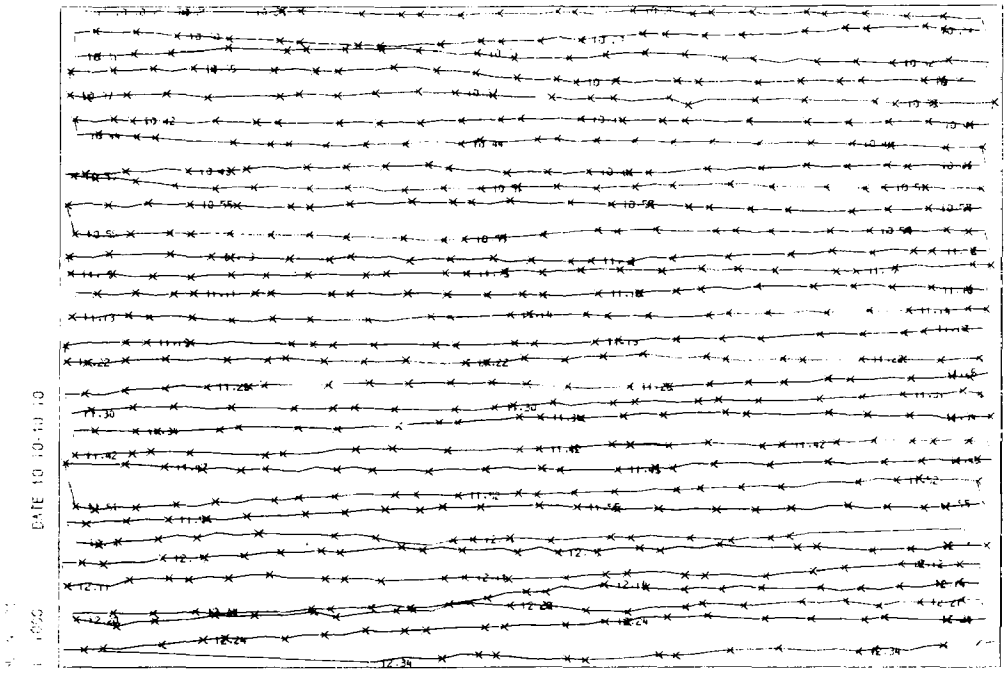

FIG. 10. — Track chart.

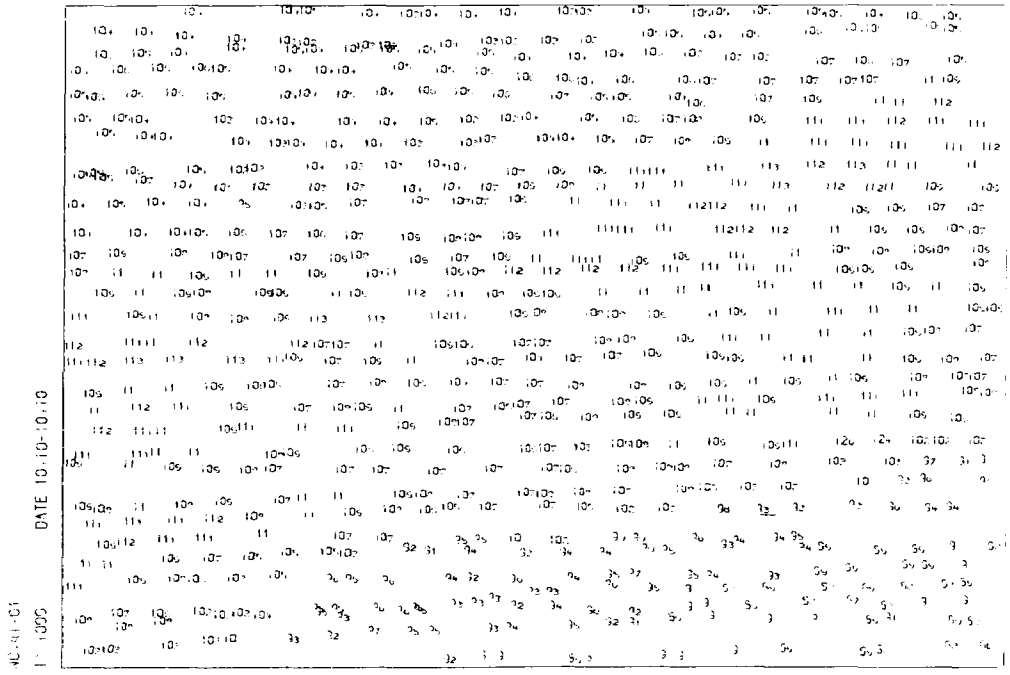

FIG. 11. — Smooth sheet.

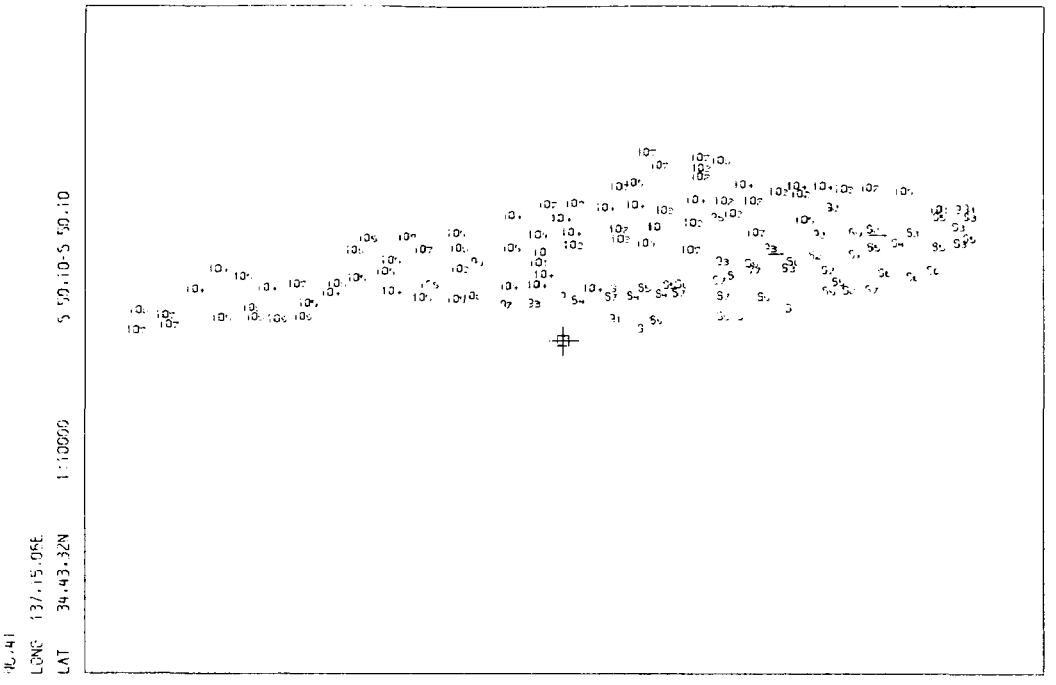

FIG. 12. — Reduced smooth sheet.

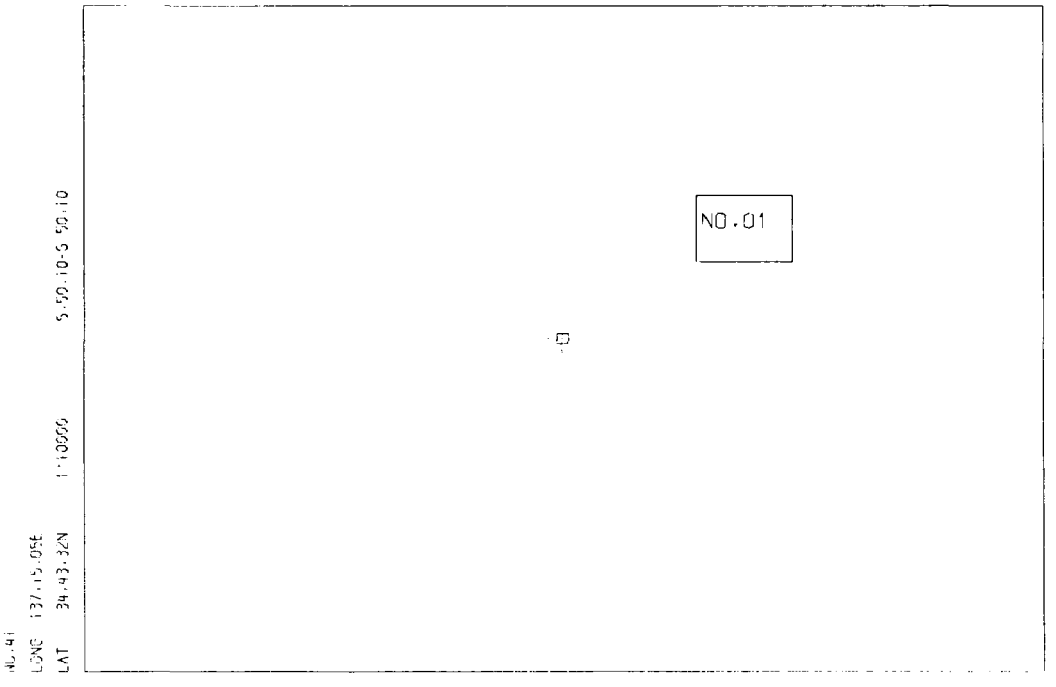

FIG. 13. — Index chart.

Soundings for a depressed part of the sea bottom might not be shown on this smooth sheet due to the automatic selection of soundings, so that a blank portion may appear on the sheet. It is possible to fill such a blank area by adding selected soundings as described above in "Survey Data Revising".

Even in a case where a detailed survey was carried out with closer sounding lines and higher accuracies in position fixing and sounding, a fairly small-scale smooth sheet is required. For this, it is possible for the system to divide the survey area into 5 mm square sub-sections on the large-scale smooth sheet, and to select automatically the minimum sounding within a sub-section, for plotting in that position. Fig. 12 shows an example of a smooth sheet of the survey area at 1:10 000, including the area shown in fig. 11. Deletion and addition of plotted soundings are also practicable in this case.

Fig. 13 is an index chart, also automatically drafted by the system, showing the relationship between the large-scale and small-scale sheets.

When the preparation of a smooth sheet is completed, the entire data used for preparation are printed out by the line printer, and also they are filed and stored on CMT.

CONCLUSION

The above-described data acquisition/processing system for hydrographic survey is a first generation one; construction was completed in autumn 1975. The technical and economic evaluations of the system will continue until autumn 1976.

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