BUREAU OF MINERAL RESOURCES
DEPARTMENT OF MINERALS AND ENERGY

GEOPHYSICAL SURVEYS OF THE CONTINENTAL MARGINS OF AUSTRALIA, GULF OF PAPUA AND THE BISMARCK SEA

OCTOBER 1970 TO JANUARY 1973

Surveys 5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19

DATA PROCESSING

COMPAGNIE GENERALE DE GEOPHYSIQUE
6 RUE GALVANI, 91301 - MASSY - FRANCE

Record 1974/110

MARINE GEOPHYSICAL SURVEY OF THE CONTINENTAL MARGINS OF AUSTRALIA, GULF OF PAPUA AND THE BISMARCK SEA 1970 - 1973

DATA PROCESSING

by

COMPAGNIE GENERALE DE GEOPHYSIQUE

SUMMARY

(by J. Pinchin, B.M.R.)

A marine geophysical survey of much of the Australian continental margin, the Gulf of Papua and the Bismarck Sea was conducted by Compagnie Generale de Geophysique (C.G.G.) under contract to the Bureau of Mineral Resources between September 1970 and January 1973. The work was divided for administrative convenience into eleven surveys, the Gulf of Papua and Bismark Sea numbered 5 and the continental margin, numbered 10 to 19. A total of 100 000 nautical miles was traversed in waters between about 50 m and 4500 m deep at a line spacing which varied from 10 nautical miles in the Gulf of Papua to 20 nautical miles off the east coast of Australia and 30 nautical miles in the west

All of the data, except seismic, were acquired in digital form on magnetic tape using small electronic computers to control and monitor the input. All important measurements were recorded also in analogue chart form, both for monitoring the measurements and for backup in case of failure of the digital system.

The primary navigation control was performed by a satellite Doppler system, and continuous positions were obtained by the use of sonar Doppler equipment to interpolate between the satellite fixes. For backup to the sonar Doppler, a Chernikeeff electromagnetic log and pressure log were operated continuously. The outputs from the Sonar Doppler and logs were recorded on the digital tape along with the gyrocompass bearings.

Total magnetic field measurements were made using a proton precession magnetometer with the sensor towed about 200 m behind the ship. Gravity measurements were made with a LaCoste & Romberg marine gravity meter mounted on a gyro-stabilized platform near the centre of the ship The seismic system comprised of a six-channel cable and a single-channel cable both connected through a standard seismic amplifier bank to an analogue magnetic tape recorder and analogue chart recorders. The seismic energy source was a 120 kilojoule sparker. Water depths were measured by two depth sounders, one designed for shallow water and the other for deep water.

This report describes briefly two data acquisition programs used successively during the survey, and phases I and II of the subsequent office processing of the navigational, gravity and magnetic data.

The data were acquired using a Hewlett Packard 2116B computer on board ship. All non-seismic data were sampled at 10 second intervals, re-formatted into 32

channels and digitally recorded using the data acquisition program This program also computed the dead-reckoned position and provided an analysis of the data reliability and a printout of data values for on-board use in quality control, plotting and further computations.

Phase I of the office system converted the field tape into standard C.D.C. 3600 or 6600 tape format, removed errors such as gaps or spikes from the data and replaced lost data by those digitized from the analogue charts. It also ensured that the recorded time values were in sequence.

The purpose of Phase II was to re-sample the data at one minute intervals, correct the gravity measurements for the Eotvos effect, and to interpolate the ship's position between the satellite fixes.

Phases III and IV are to be done later by BMR. They include correcting for navigation errors, reducing the misties at intersections by statistical methods and producing final contour maps and profiles.

This report was written by Compagnie Generale de Geophysique. The views expressed are not necessarily those of the Bureau of Mineral Resources.

BUREAU OF MINERAL RESOURCES

DEPARTMENT OF MINERALS AND ENERGY

GEOPHYSICAL SURVEYS OF THE CONTINENTAL MARGINS OF AUSTRALIA, GULF OF PAPUA AND THE BISMARK SEA.
CAPO No. 560663 and 560585

October 1970 - January 1973

PROCESSING REPORT

COMPAGNIE GENERALE DE GEOPHYSIQUE
6 Rue Galvanı - Massy FRANCE

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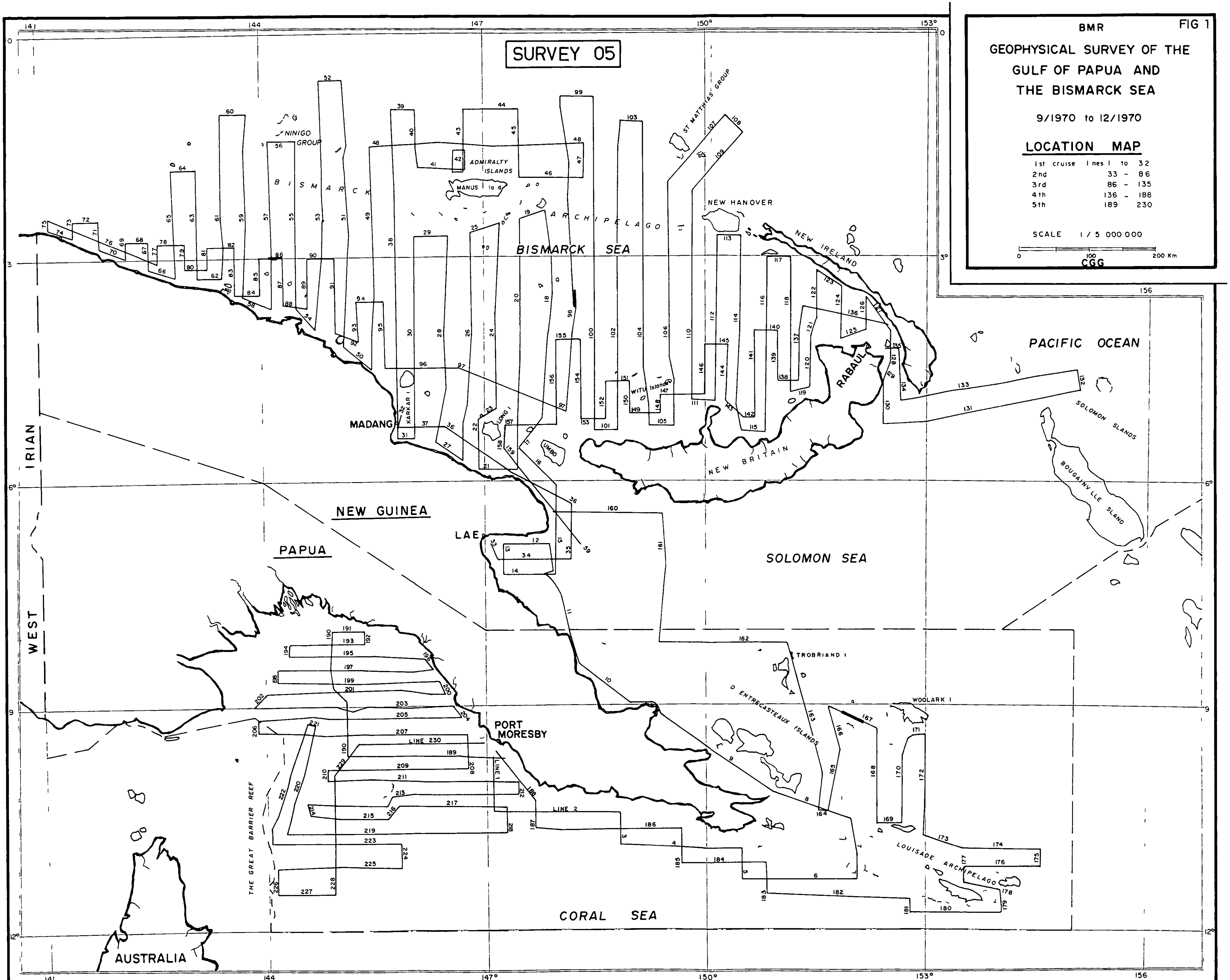
INTRODUCTION

The combined marine geophysical surveys of the Gulf of Papua and the Bismark sea and of the Continental margins of Australia were carried out from September 4th 1970 to January 6th 1973 by Compagnie Generale de Geophysique for the Bureau of Mineral Resources, Department of National Development of the Commonwealth of Australia.

The aim of this report is to describe the main steps and programmes of the computer processing of the above surveys. When quoted in the report, the geophysical survey of the Gulf of Papua and the Bismark sea will be called Survey 05, the geophysical survey of the Continental margins of Australia will be represented by Surveys 10 to 19. Figures 1 and 2 give a breakdown of the different areas.

Processing of these surveys was carried out first on the C.D.C 3600 of the C.S.I.R.O. in Canberra, then on the C.D.C. 6600 in Sydney, a terminal being available at the Bureau of Mineral Resources. Programmes were written in FORTRAN language, except special subroutines written in C.D.C. assembly language COMPASS.

The main divisions of the report are as follows Ship-board acquisition is first described, then phases I and II, phase I begins when a magnetic tape is received from the ship, phase II ends when the data on the output tape are stored in a special format necessary to carry out further processing with B.M.R. programmes. Finally, a description is given of special programmes designed for use out of the main flow of processing.



BMR
FIG 1
GEOPHYSICAL SURVEY OF THE
GULF OF PAPUA AND
THE BISMARCK SEA
9/1970 to 12/1970
LOCATION MAP
1st cruise lines 1 to 32
2nd 33 - 86
3rd 86 - 135
4th 136 - 188
5th 189 - 230
SCALE 1/5 000 000
0 100 200 Km
CGG
SURVEY 05
NINIGO GROUP
ADMIRALTY ISLANDS
MANUS I
BISMARCK ARCHIPELAGO
BISMARCK SEA
ST MATTHIAS GROUP
NEW HANOVER
NEW IRELAND
PACIFIC OCEAN
RABAUL
WITU Islands
KARKAR I
MADANG
LONG I
UMBOI
NEW BRITAIN
SOLOMON SLANDS
BOUGAINVILLE SLAND
IRIAN
WEST
NEW GUINEA
PAPUA
LAE
SOLOMON SEA
TROBRIAND I
D ENTRECASTEAUX ISLANDS
WOOLARK I
PORT MORESBY
LINE 230
LINE 1
LINE 2
LOUISADE ARCHIPELAGO
THE GREAT BARRIER REEF
CORAL SEA
AUSTRALIA

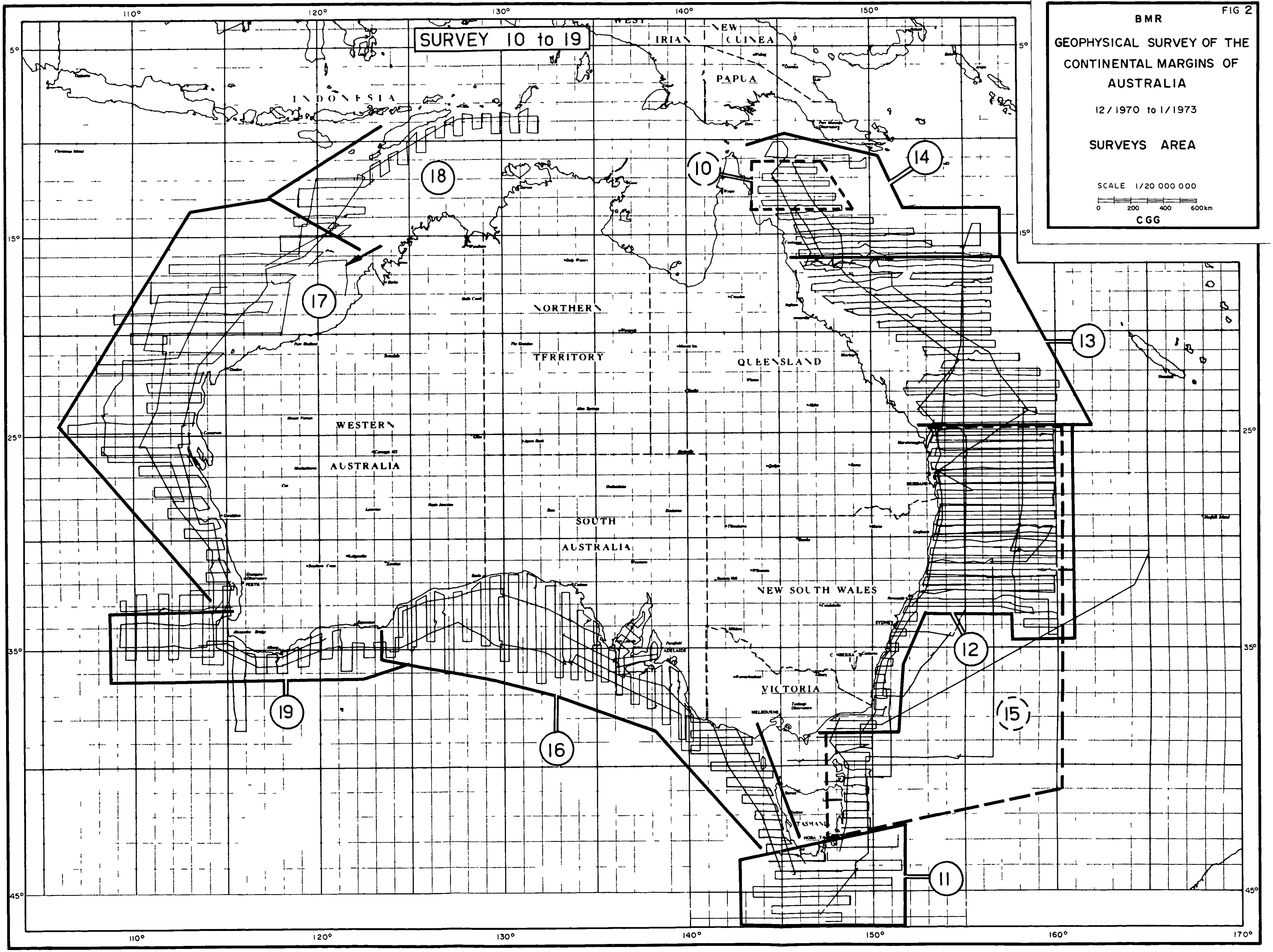


FIG 2

BMR

GEOPHYSICAL SURVEY OF THE CONTINENTAL MARGINS OF AUSTRALIA

12/1970 to 1/1973

SURVEYS AREA

SCALE 1/20 000 000

0 200 400 600 km

CGG

I. DATA ACQUISITION PROGRAMMES

During the surveys, two programmes were successively used first, C.G.G.'s MISER (from survey 05 to survey 16), and then B.M.R.'s JOY (from survey 17 to survey 19). In the two programmes, the following functions are performed

* Formating and recording, in digital form, of all non seismic data, i e. 32 channels. Sampling rate 10 seconds.

* Maintenance of an analysis of the reliability of the data recorded.

* Maintenance of dead reckoning.

* Production of regular print-outs required for checking and/or computation of results on board.

The computer used was a Hewlett-Packard 2116 B.

I 1 - MISER characteristics

* Ability, at any time, to print out, one by one, the instantaneous value of each channel This allows analogue to digital cross checking.
* Ability, at any time, to change the calibration (origin and slope) of the 20 channels recorded in analogue form.
* Ability at any time to modify the rate of change and the threshold which is the criterion of reliability for each of the 32 channels recorded Every new value is compared to the previous one within the gate defined by the rate of change plus or minus the threshold. If the criterion is not satisfied, an error counter is incremented.
* Maintenance of three systems of dead reckoning
    - Sonar Doppler.
    - Chernikeeff Log plus compass.
    - Pressure Log plus compass.

These are reset via the teleprinter at satellite fix times.

* Systematic 10 minutes print out of
    - values of the 32 channels (play back of the tape).
    - content of the 32 error counters.
    - positions of the ship according to the three systems of dead reckoning.

* The generated tape contains blocks of data consisting of 15 scans, each scan containing 32 values, each represented by 2 H.P. words in floating point format. Each word is then stored onto the magnetic tape as three characters with one bit common to consecutive characters (Fig. 3)

I .2. JOY characteristics.

* Three possible states labelled 1,2 or 3.

STATE	DATA IN	DATA OUT TO TAPE
1	No	No
2	Yes	No
3	Yes	Yes

* Data input to the computer is recorded onto magnetic tape unaltered, but data out to teleprinter and used in core for dead reckoning computations may be multiplied by convenient scaling factors.

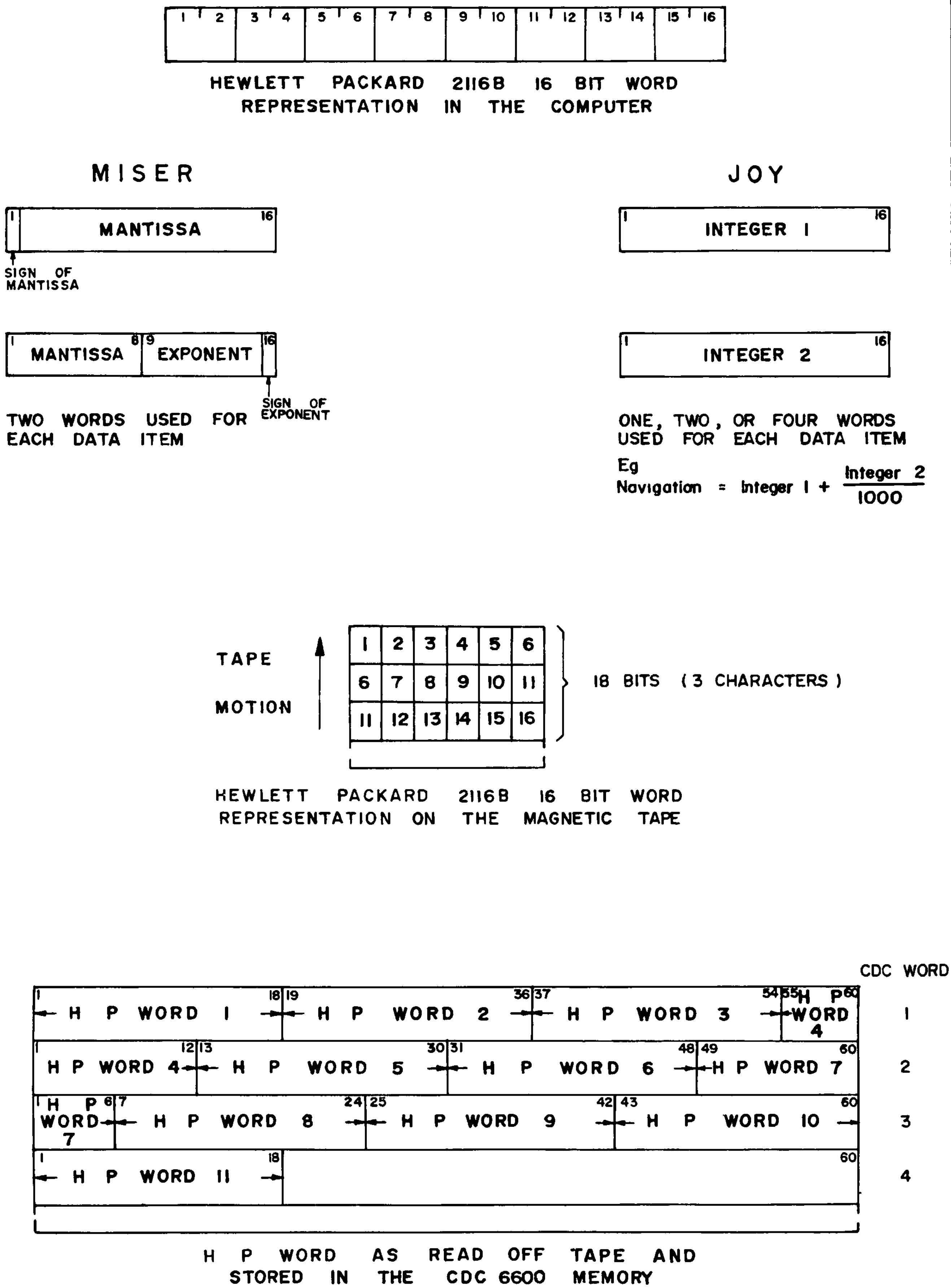
* Dead reckoning is computed every 10 minutes.

* If the time interval between 2 consecutive satellite fixes is less than 6 hours, then the programme computes a corrected post navigation and carries out geophysical computations such as. free air anomaly, Bouguer anomaly and magnetic anomaly.

* Possibility to perform a dump of the content of core memory.

* Through a routine, the user can force a synchronisation of the time if the programme has failed to do so.

FIG 3



DATA TAPE FORMAT

*   The generated tape consists of 16 scans of 32 channels of data wherein the first scan of each block is a duplicate of the last scan of the preceding block. Each channel of data is recorded using from one to four Hewlett Packard words of integer format, and then written onto magnetic tape as three characters per word. (Fig. 3)

In both programmes, the content of each channel is the same. A listing is given in Appendix 1.

II - PHASE I.

Errors are present in the data collected on board the ship. The purpose of Phase I is to correct these errors with the object of having a 10 second data tape representing as nearly as possible the true values being measured by the various sensors at the time of recording.

The three main programmes of Phase I are: (see fig.4)

- CATCH: converting the field tape.
- PREVEW: automatic error removal.
- MISDAT: final error removal and inclusion of digitized or manually provided data.

II - 1 - CATCH

The purpose of this programme is to read the field tapes and convert the data to standard C.D.C. 3600 or 6600 format.

As the field tapes contain various anomalies, whilst reading and converting them, CATCH has also to perform some additional error detection and correction processes.

II - 1 - 1. Problems encountered and additional processes.

* The field tapes do not always have a label.

  - On the C.S.I.R.O. C.D.C. 3600, the only solution was repeated running of the programme reading the tape.

  - The C.D.C. 6600 reads these tapes with no problem.

* Parity errors when reading the field tape.

  - The C.S.I.R.O. system was unable to handle this problem in FORTRAN; therefore a programme had to be written in COMPASS.

  - FORTRAN on the C.D.C. 6600 is of a level of sophistication that can cope with this problem.

* When the field tape was written, there occurred three inter-related problems:

  (i) short interrecord gaps.

  (ii) noise before data in a record which appears to the programme reading the tape as character or frame-shift.

  (iii) tape skew problem.

The programme on the C.S.I.R.O. system was suitable only for data collection for Survey 05 since it used the fact that channels 21, 23, 29, 31 should contain zero to position the data within the record.

The C.D.C. 6600 is more tolerant of such problems; therefore, CATCH was written to utilise the following procedures:

a - Rereading of the record of data

b - Searching for the channel that gives the least number of time sequence errors and defining this channel as the time channel.

c - Rejecting short records.

d - Detailed exception reporting.

* For various reasons, the time value recorded on the tape could become erratic.

On the C.S.I.R.O. system, the programme assumed that the time jump required correction by an exact multiple of 24 hours, positive or negative, as this was the most common occurance.

CATCH on the C.D.C. 6600 interpolated the time if no more than three consecutive values were inconsistent, otherwise it reported full details and correction cards were introduced into the following programme, PREVEW, to overcome the problem.

* For surveys 17, 18 and 19, if a clock beat is lost, then for all channels, each Hewlett Packard character on tape is 77 octal. The record is sometimes written on tape with these

characters, for all channels in the last part of the record and then, the next record written has these characters in the first part of the record.

No processing of these tapes, in production work, was carried out on the C.S.I.R.O system.

The C.D.C. 6600 CATCH had to be sophisticated to deal with this problem and then, sometimes, short records would be rejected.

* Also for Surveys 17, 18 and 19, random END OF FILE (E.O.F) marks among the data records, compounded by no E.O.F. at the end of the data, created an additional problem that was solved in the following way on the C.D.C. 6600 system:

First, CATCH required a check for the random E.O.F marks and an option to read a fixed number of records single buffered.

Second, a small programme was written that read the tape, printing the label and then, searching for two consecutive E.O.F. marks. If this condition was not met, then the tape ran off the end of the tape reel, but the number of records was found.

* Various of the previously mentioned problems in using the field tape on the C.D.C. 6600 caused an additional complication. When the data was converted to C.D.C. 6600 format, any arithmetical operation with it could cause a computer hard-

FIELD TAPE ERROR REPORT.

**********	NON-SEQUENTIAL TIMES -	0.0000	FOLLOWED BY 1003.1240	IN LINE	1

LENGTH ERROR IN INPUT BLOCK NO 53, LENGTH= 261

LENGTH IS THE NUMBER OF CDC 6600 WORDS REQUIRED TO HOLD THE HP BLOCK : 298 in normal case

PARITY ERROR IN INPUT BLOCKNO 54

LENGTH ERROR IN INPUT BLOCK NO 54, LENGTH= 8

**********	NON-SEQUENTIAL TIMES -	1005.2230	FOLLOWED BY 1014.5740	IN LINE (SCAN)	1

LENGTH ERROR IN INPUT BLOCK NO 67, LENGTH= 168

**********	NON-SEQUENTIAL TIMES -	1015.2730	FOLLOWED BY 1103.1240	IN LINE	1

LENGTH ERROR IN INPUT BLOCK NO 349, LENGTH= 186

**********	NON-SEQUENTIAL TIMES -	1114.5500	FOLLOWED BY -101.0100	IN LINE	1
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	2
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	3
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	4
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	5
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	6
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	7
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	8
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	9
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY 1114.5640	IN LINE	10

CATCH FIELD TAPE ERROR REPORT

LENGTH ERROR IN INPUT BLOCK NO 376, LENGTH= 242

**********	NON-SEQUENTIAL TIMES -	1116.0000	FOLLOWED BY -101.0100	IN LINE	1
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	2
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	3
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	4
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	5
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	6
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	7
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	8
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	9
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	10
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	11
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	12
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY 1116.0210	IN LINE	13

BLOCK WITH 13 TIME FAULTS - DELETED. BLOCK NO 377

LENGTH ERROR IN INPUT BLOCK NO 548, LENGTH= 242

**********	NON-SEQUENTIAL TIMES -	1123.0730	FOLLOWED BY -101.0100	IN LINE	1
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	2
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	3
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	4
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	5
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	6
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	7
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	8
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	9
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	10
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	11
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY -101.0100	IN LINE	12
**********	NON-SEQUENTIAL TIMES -	-101.0100	FOLLOWED BY 1123.0940	IN LINE	13

FIG. 5

ware error. This was remedied by an additional routine in the programme MISDAT.

II - 1 - 2. CATCH outputs.

i - Magnetic tape.

It consits of 60 scans blocks, each scan being 32 values; if gaps in time of 1 or 2 scans have occurred, the value 1.0 E10 will have been substituted in channels 2 to 32, otherwise the data will not have been altered. Input blocks from the field tape with the correct length and the wrong parity will still be utilised, but if the length is short, it will be ignored.

Tape format is given in Appendix I.

ii - Reports.

The first one (fig. 5) notifies errors on the field tape of the following type:

parity
block length
time sequence errors
time misalignments.

The second one notifies points with time breaks that have not been corrected by CATCH and indicates extent of time corrections performed if any. Histograms are also produced of channel differences between each sample. (Fig. 6 and 7).

II - 1 - 3. CATCH assessment.

The reports provide information to determine the values to be input by cards to the next programme PREVEW and

CATCH PRINT-OUT

SURVEY 19

THE PRINT-OUT " CHANNEL CONVERSION MATRIX " EXISTS ONLY FOR MAGNETIC TAPES RECORDED WITH THE D.A.S. PROGRAMME "JOY"

CHANNEL CONVERSION MATRIX

CATCH CHANNEL	1	USES HP CHANNELS	1	2	3	4
CATCH CHANNEL	2	USES HP CHANNELS	5	0	0	0
CATCH CHANNEL	3	USES HP CHANNELS	6	0	0	0
CATCH CHANNEL	4	USES HP CHANNELS	7	0	0	0
CATCH CHANNEL	5	USES HP CHANNELS	8	0	0	0
CATCH CHANNEL	6	USES HP CHANNELS	9	10	0	0
CATCH CHANNEL	7	USES HP CHANNELS	11	12	0	0
CATCH CHANNEL	8	USES HP CHANNELS	13	14	0	0
CATCH CHANNEL	9	USES HP CHANNELS	15	16	0	0
CATCH CHANNEL	10	USES HP CHANNELS	17	18	0	0
CATCH CHANNEL	11	USES HP CHANNELS	19	20	0	0
CATCH CHANNEL	12	USES HP CHANNELS	21	22	23	24
CATCH CHANNEL	13	USES HP CHANNELS	25	0	0	0
CATCH CHANNEL	14	USES HP CHANNELS	26	0	0	0
CATCH CHANNEL	15	USES HP CHANNELS	27	0	0	0
CATCH CHANNEL	16	USES HP CHANNELS	28	0	0	0
CATCH CHANNEL	17	USES HP CHANNELS	29	0	0	0
CATCH CHANNEL	18	USES HP CHANNELS	30	0	0	0
CATCH CHANNEL	19	USES HP CHANNELS	31	0	0	0
CATCH CHANNEL	20	USES HP CHANNELS	32	0	0	0
CATCH CHANNEL	21	USES HP CHANNELS	33	0	0	0
CATCH CHANNEL	22	USES HP CHANNELS	34	0	0	0
CATCH CHANNEL	23	USES HP CHANNELS	35	0	0	0
CATCH CHANNEL	24	USES HP CHANNELS	36	0	0	0
CATCH CHANNEL	25	USES HP CHANNELS	37	0	0	0
CATCH CHANNEL	26	USES HP CHANNELS	38	0	0	0
CATCH CHANNEL	27	USES HP CHANNELS	39	0	0	0
CATCH CHANNEL	28	USES HP CHANNELS	40	0	0	0
CATCH CHANNEL	29	USES HP CHANNELS	41	0	0	0
CATCH CHANNEL	30	USES HP CHANNELS	42	0	0	0
CATCH CHANNEL	31	USES HP CHANNELS	43	0	0	0
CATCH CHANNEL	32	USES HP CHANNELS	44	0	0	0

```
START OF SEGMENT NUMBER   1.  TIME =  1003.1240
CHANNELS 2-11:      390.400   497.000   528.000   390.900  60902.000   -10.144   10.472   14.560   9.500   237.000
////EOF=RECORD   53////(X=   1Z=   2)
```

X = 1 NUMBER OF CONSECUTIVE E.O.F
Z = 2 LIMIT " " " TO STOP THE RUN

FOR SURVEY >17 ONLY

```
  END OF SEGMENT NUMBER   1.  TIME =  1005.2230
CHANNELS 2-11       425.500   499.000   514.000   421.400  32000.000   -20.224   -1.531   28.210   25.400   230.000
NO OF REJECTED SCANS =     0.  NO OF ADJUSTMENT OCCASIONS =    0
NO OF INSERTED DUMMIES =     0.  NO OF INSERTION OCCASIONS =    0
```

TIME BREAK

```
START OF SEGMENT NUMBER   2.  TIME =  1014.5740
CHANNELS 2-11:      397.700   499.000   479.000   407.300  61062.000   -17.044   -.955   55.700   66.700   348.000
////EOF=RECORD   67////(X=   1Z=   2)

  END OF SEGMENT NUMBER   2.  TIME =  1015.2730
CHANNELS 2-11       433.000   496.000   518.000   436.700  63148.000   -18.526   -4.247   59.240   71.100   226.000
NO OF REJECTED SCANS =     0.  NO OF ADJUSTMENT OCCASIONS =    0
NO OF INSERTED DUMMIES =     0.  NO OF INSERTION OCCASIONS =    0
```

FIG. 6

DIFFERENCE ANALYSIS TABLE

CATCH HISTOGRAMME

CHANNEL NO	1		2		3		4		5		6		7		8	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	9	0	27886	0	34544	0	4123	0	20733	0	11856	0	5099	0	10150	0
.0010	0	0	0	0	0	0	0	0	0	0	0	0	4162	2568	7299	6089
.0020	63777	0	0	0	0	0	0	0	0	0	0	0	1740	490	4513	2807
.0039	0	0	0	0	0	0	0	0	0	0	0	0	7677	115	1596	833
.0078	0	0	0	0	0	0	0	0	0	0	0	0	5645	949	2701	363
.0156	0	0	0	0	0	0	0	0	0	0	0	0	17841	17494	25558	1874
.0313	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0625	0	0	6920	8425	0	0	0	0	6433	6860	0	0	4	3	5	0
.1250	0	0	3789	4092	0	0	0	0	4209	4462	0	0	0	0	0	0
.2500	0	0	3697	3196	0	0	0	0	4620	4733	0	0	1	1	1	0
.5000	0	0	2273	2070	0	0	0	0	3354	3117	0	0	0	0	1	0
1.0000	0	0	592	609	11956	10603	1564	1514	741	791	8191	8290	0	0	0	0
2.0000	0	0	51	150	2885	3114	3099	3155	92	189	9196	9598	2	0	0	0
4.0000	0	0	1	1	223	369	5600	5692	693	779	4949	5179	0	0	1	0
8.0000	2	0	3	3	12	24	8782	9026	1025	936	2220	2151	0	0	0	0
16.0000	0	0	2	3	0	1	8973	8860	0	0	830	859	0	0	1	1
32.0000	0	0	0	0	2	2	1647	1643	0	0	211	182	1	1	1	1
64.0000	0	0	3	3	26	26	49	52	3	3	28	15	0	0	0	0
128.0000	0	0	0	0	0	0	8	2	0	0	2	2	0	0	0	0
256.0000	1	1	1	1	4	4	3	2	1	1	1	0	0	0	0	0
512.0000	0	0	8	8	0	0	0	1	3	3	3	3	0	0	0	0
1024.0000	1	1	4	4	0	0	0	0	7	7	18	11	1	1	0	0
0.0000	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795

CHANNEL NO	9		10		11		12		13		14		15		16	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	9	0	48523	0	19607	0	13785	0	63793	0	63793	0	63793	0	63793	0
.0010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0078	5457	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0156	58313	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0313	1	1	0	0	0	0	547	571	0	0	0	0	0	0	0	0
.0625	2	1	15240	0	0	0	778	798	0	0	0	0	0	0	0	0
.1250	0	0	22	0	0	0	1439	1398	0	0	0	0	0	0	0	0
.2500	3	0	4	0	0	0	3102	3148	0	0	0	0	0	0	0	0
.5000	0	0	0	0	0	0	4963	5060	0	0	0	0	0	0	0	0
1.0000	0	0	0	0	13366	13317	4583	4832	0	0	1	1	0	0	0	0
2.0000	0	0	0	0	6865	6979	2945	3032	0	0	0	0	0	0	0	0
4.0000	0	0	0	0	533	577	2139	2267	0	0	0	0	0	0	0	0
8.0000	0	0	0	0	77	80	1548	1776	0	0	0	0	0	0	0	0
16.0000	1	0	0	0	6	0	764	1003	0	0	0	0	1	1	0	0
32.0000	1	0	2	0	1	0	735	1244	0	0	0	0	0	0	0	0
64.0000	0	0	0	0	1	0	196	373	0	0	0	0	0	0	0	0
128.0000	1	1	1	1	1	1	137	149	0	0	0	0	0	0	0	0
256.0000	0	0	1	1	1192	1192	187	148	0	0	0	0	0	0	0	0
512.0000	0	0	0	0	0	0	67	32	0	0	0	0	0	0	0	0
1024.0000	1	1	0	0	0	0	26	23	1	1	0	0	0	0	1	1
0.0000	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795	0	63795

FIG. 7

give a quick assessment of the state of the data recorded.

The cards prepared are:

i - Time correction cards

ii - Threshold cards for each channel to be processed,(i.e de-spiked):

Maximum and minimum limits

Thresholds allowed between samples.

II - 2. PREVEW.

The purpose of this programme is to read the output tapes from CATCH and to perform time corrections and automatic editing.

The output from PREVEW consists of two tapes: an updated tape (PRE) and a tape only time corrected (PRP) for plotting purposes.

The PREVEW report allows further correction by various ways of all remaining anomalies recorded on tape.

Due to various problems encountered during the two surveys, several optional possibilities are available in PREVEW to permit a special reprocessing of portion(s) of data.

II - 2 - 1. Processing, problems encountered.

i - Standard processes.

* The programme CATCH has reported when it cannot correct time - errors; therefore,parameter cards are input into

PREVEW to enable the CATCH tape to be formed into exact 10 minute blocks with 10 second scans, each block commencing on an exact multiple of 10 minutes. If gaps still exist, the time values are made continuous and the data channels are filled with the value 1.0 E10. When the gap is in excess of 1 hour, dummy blocks are not provided.

* Navigation data channels (7, 8, 9 and 10), which were recorded in integrated values, are replaced by incremented values, thus a discontinuous trace is replaced by a continuous trace with spikes. The advantages of this method are as follows:

- A discontinuity on the integrated trace will be replaced by a spike on the incremental trace. Thus, the spike will be easily removed by the programme PREVEW. (the discontinuity cited above can be, for example, an accidental reset of any of the navigation equipment).

- If a gap remains after PREVEW has been applied, an automatic interpolation will conditionally be performed in the following programme MISDAT.

* The Gravity and Spring Tension channels are recorded only in the range zero to two thousand; therefore, a base value provided on a parameter card is added.

* The ship's heading is not processed directly but its sine and cosine are computed and stored in channels 21 and 29; these values are subsequently processed in lieu of channel 11. The essence of the method is that the discontinous function (heading) is replaced by two continous functions. Automatic interpolation of a noisy discontinuous function is difficult

PREVEW

R START TIME= 1514.10, FINISH TIME = 2010.50

S GRAVITY BASE= 1000., S.T. BASE= 6000., COMPASS BASE= 0.

U CHANNEL NO=	2, ALPHA=	7000.000, BETA=	9000.000, EPSILON-1=	3.000, EPSILON-2=	3.000
U CHANNEL NO=	3, ALPHA=	0.000, BETA=	1000.000, EPSILON-1=	4.000, EPSILON-2=	4.000
U CHANNEL NO=	5, ALPHA=	7000.000, BETA=	9000.000, EPSILON-1=	3.000, EPSILON-2=	3.000
U CHANNEL NO=	6, ALPHA=	0.000, BETA=	100000.000, EPSILON-1=	8.000, EPSILON-2=	8.000
U CHANNEL NO=	7, ALPHA=	-.040, BETA=	.040, EPSILON-1=	.040, EPSILON-2=	.040
U CHANNEL NO=	8, ALPHA=	-.040, BETA=	.040, EPSILON-1=	.040, EPSILON-2=	.040
U CHANNEL NO=	9, ALPHA=	-.040, BETA=	.040, EPSILON-1=	.040, EPSILON-2=	.040
U CHANNEL NO=	10, ALPHA=	-.180, BETA=	.180, EPSILON-1=	.180, EPSILON-2=	.180
U CHANNEL NO=	12, ALPHA=	0.000, BETA=	10000.000, EPSILON-1=	50.000, EPSILON-2=	50.000
U CHANNEL NO=	21, ALPHA=	-1.010, BETA=	1.010, EPSILON-1=	.120, EPSILON-2=	.120
U CHANNEL NO=	29, ALPHA=	-1.010, BETA=	1.010, EPSILON-1=	.120, EPSILON-2=	.120
U CHANNEL NO=	0, ALPHA=	-0.000, BETA=	-0.000, EPSILON-1=	-0.000, EPSILON-2=	-0.000

PREVEW PRINTOUT

Standard processing parameters

SURVEY 19

FIG. 8

to do reliably. The advantage of this method is as follows:

- let suppose a sudden change in heading from 10^o to 355; the programme PREVEW will desynchronise and then will synchronise again; thus a gap will be created; this gap could (or might) be automatically filled in the programme MISDAT by linear interpolation; this interpolation would be performed in the following way:

10, 11, 12 .... 353, 354, 355, which is, obviously wrong.

- Now, let consider the same problem and its solution when heading has been converted into its sine and cosine:

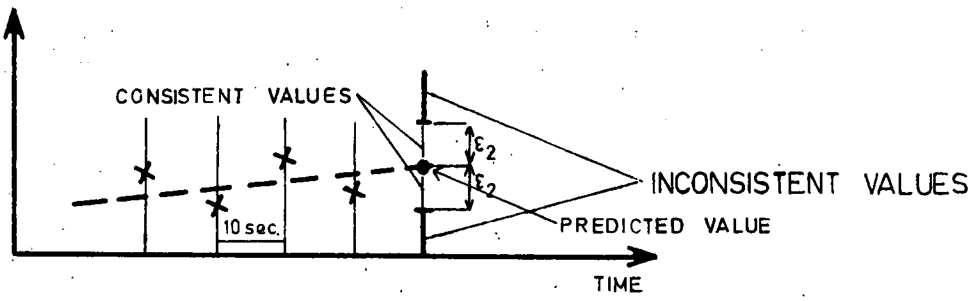
$$\text{Sin } 10^o = 0.17365$$
$$\text{Cos } 10^o = 0.98481$$
$$\text{Sin } 355^o = -0.08716$$
$$\text{Cos } 355^o = 0.99619$$

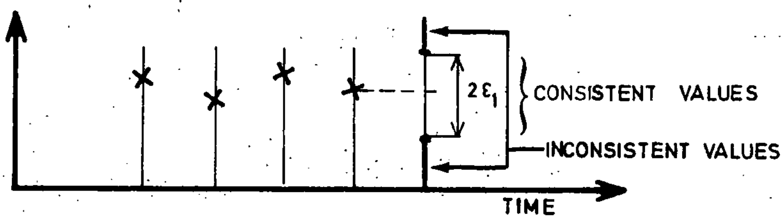
The cosine trace will not be affected by the PREVEW processing. A desynchronisation will occur on the sine trace and a gap will be created. If the gap is short, it is considered that the sine varies linearly (a small portion of the curve Sin x may be approximated to a straight line) and that, for each scan, $\sin^2 + \cos^2 \simeq 1$; thus, in the following programme MISDAT, automatic interpolation will be considered satisfactory.

* Channels specified by parameter cards are now processed to remove noise spikes: four parameters are required for each channel: (fig. 8).

- α, β.

- $\varepsilon_1, \varepsilon_2$.





α and β are the minimum and maximum allowable values; any value outside this range is considered bad. ε_1 and ε_2 are two threshold values described later. To check for a coherent trace in each channel, a window of four consecutive points is used which is moved along the trace. These four values are used to predict the next value by a least square method (See appendix 2). If the next value is within the threshold ε_2 of the predicted value, then the value is accepted, if not, the predicted value is put into the window. If the value is accepted, then any predicted values in the window are replaced by simple interpolation. Whilst this process continues, the oldest value in the window is written to the output tape. If the window becomes full of predicted values, a new process takes place; first, the original data plus 1.0 E10 is written to the output tape, and then this process continues until the window is filled by four values satisfying the condition that consecutive values must be within the threshold ε_1, together with the limitation implied by α and β.

ii. Optional processes: if they are required, they are applied to the time cleaned data before the plot tape is written.

* The processing specified in paragraphs 2, 3, 4 of standard processes may be suppressed. This allows for reprocessing the PREVEW output. An example of the requirement to reprocess the data from PREVEW back again through PREVEW occurs when bit recovery is required (see below). In reprocessing the data, we will wish to suppress the addition of a base value to the Gravity and Spring Tension.

* Before the sine and cosine of the heading are computed, the data in channels 21 and 29 may be saved elsewhere.

* A specified number of records with bad parity may be processed. (If not required, processing stops when bad parity is read).

* The depths may be modified:

- a constant number (a) may be added,
- the depths may be multiplied by a constant factor (b), (Example: ELAC=1.01125 RAYTHEON)
- a constant number (a) may be added after the original depths have been multiplied by a constant factor (b).

(a) and (b) are two parameters read from input cards.

* The data in any channel may be smoothed using a moving median and/or a moving average algorithm; the resulting value may be shifted (if required) with respect to the time channel. (Figures 9 to 12B in Appendix 3).

* The data in any channel may be despiked and then filtered

PLOT OF SPRING TENSION WITH SIMULTANEOUS DROPS OF BITS : 3(-4) AND 4(-8)

AN EXAMINATION OF THE PLOTS PRODUCED FROM THE D.A.S. TAPES SHOWED THAT ENCODER WAS NOT ALWAYS WORKING CORRECTLY. THE DATA IS ENCODED, DIGIT BY DIGIT INTO ITS BINARY EQUIVALENT BEFORE RECORDING ONTO THE MAGNETIC TAPE AND IT IS THIS CONVERSION TO BINARY THAT MALFUNCTIONED. THE DIGITS 0 to 9 SHOULD BE ENCODED THUS :

0000 = 0	0001 = 1	0010 = 2	0011 = 3	0100 = 4
0101 = 5	0110 = 6	0111 = 7	1000 = 8	1001 = 9

FOR THE PURPOSE OF THE FOLLOWING EXPLANATION WE DEFINE THE 4 BITS POSITION FROM LEFT TO RIGHT AS BITS 4, 3, 2, 1.

THE PROBLEM ALWAYS PRESENTED ITSELF AS ENCODING A ZERO BIT WHERE A ONE BIT SHOULD HAVE BEEN, THUS ALWAYS GIVING RISE TO A VALUE LESS THAN THE CORRECT ONE ie : 5 (0101) ENCODED AS 1 (0001)

The plot clearly indicates which digit and which bit was in error. The scale of the plot gives the digit position and it is clear from the plot example under that 8 has been subtracted from a set of values (17.14.30'). This can only occur to digit values 8 and 9 (1000, 1001) which are recorded as 0 and 1 (0000, 0001) The correction programme required as parameters the channel number(s) digit position(s) and the bit(s) within the digit, it then corrected in a manner simulating visual correction. Any bit or bits in any digit or digits may be corrected but the greatest use was for "spring tension", encoded as XXXX·X with bits 4, 3 and 2 recovered in the digit to the immediate left of the decimal point (units digit).

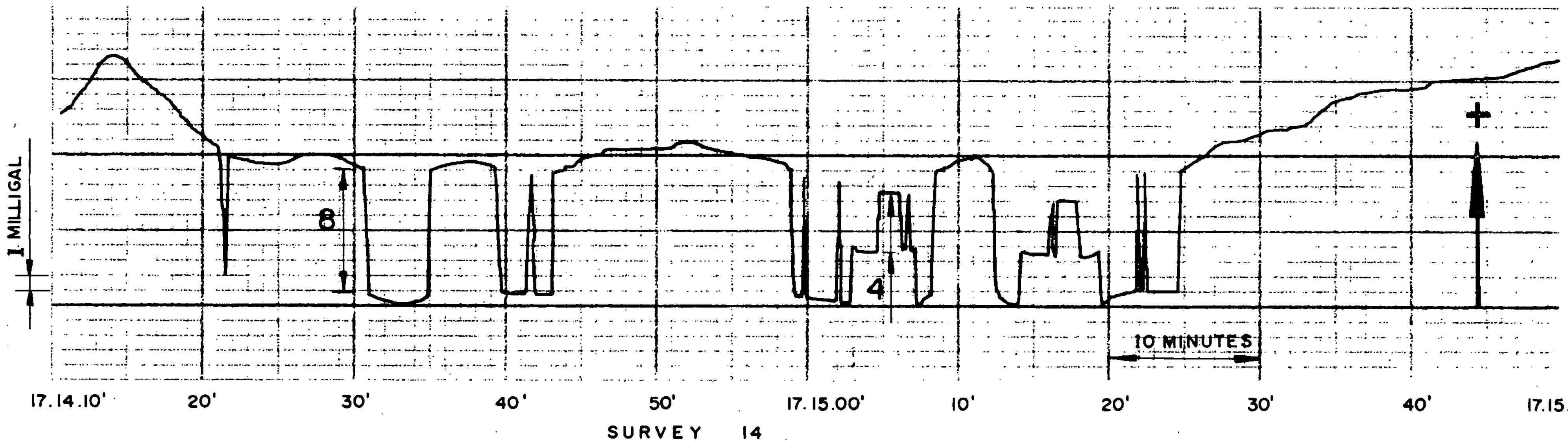


FIG. 13

PREVEW GAP REPORT

FROM 1514.10 TO 2010.50

```
SEGMENT NO=   1  CORRECTION=   0.000000 GAP FROM *89.449343 TO  15.130140

//// 1514.1000 BLOCK, CHANNEL  5 DROPPED BITS =   1 ////
//// 1514.2000 BLOCK, CHANNEL  5 DROPPED BITS =   9 ////

BLOCK NO    1, BLOCK START TIME = 1514.1000
CHAN.=  2, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=   8277.700, V(1)= *00000.000, V(60)=   8287.900
CHAN.=  3, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=    496.000, V(1)= *00000.000, V(60)=    500.000
CHAN.=  5, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=   8281.600, V(1)= *00000.000, V(60)=   8295.400
CHAN.=  6, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=  60512.000, V(1)= *00000.000, V(60)=  60655.000
CHAN.=  7, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=       .024, V(1)= *00000.000, V(60)=       .025
CHAN.=  8, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=       .001, V(1)= *00000.000, V(60)=       .003
CHAN.=  9, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=       .020, V(1)= *00000.000, V(60)=       .020
CHAN.= 10, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=      0.000, V(1)= *00000.000, V(60)=      0.000
CHAN.= 12, EARLIEST DESYNC- T= 1514.1250, V=   1742.384, LATEST SYNC- T= 1514.1300, V=   1770.496, V(1)= *00000.000, V(60)=   1486.639
CHAN.= 21, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=       .087, V(1)= *00000.000, V(60)=       .174
CHAN.= 29, EARLIEST DESYNC- T=    0.0000, V=      0.000, LATEST SYNC- T= 1514.1040, V=       .996, V(1)= *00000.000, V(60)=       .985
//// 1514.3000 BLOCK, CHANNEL  5 DROPPED BITS =   5 ////

BLOCK NO    2, BLOCK START TIME = 1514.2000
CHAN.= 12, EARLIEST DESYNC- T= 1514.2140, V=   1405.637, LATEST SYNC- T= 1514.2240, V=   1287.422, V(1)=   1486.639, V(60)=   1034.104
//// 1514.4000 BLOCK, CHANNEL  5 DROPPED BITS =   1 ////

BLOCK NO    3, BLOCK START TIME = 1514.3000
CHAN.= 29, EARLIEST DESYNC- T= 1514.3530, V=       .358, LATEST SYNC- T= 1514.3630, V=       .017, V(1)=       .982, V(60)=      -.035

BLOCK NO    4, BLOCK START TIME = 1514.4000
//// 1515.0000 BLOCK, CHANNEL  5 DROPPED BITS =   3 ////      3 BITS OF CHANNEL  5 RECOVERED

BLOCK NO    5, BLOCK START TIME = 1514.5000

BLOCK NO    6, BLOCK START TIME = 1515.0000
//// 1515.2000 BLOCK, CHANNEL  5 DROPPED BITS =   6 ////

BLOCK NO    7, BLOCK START TIME = 1515.1000

BLOCK NO    8, BLOCK START TIME = 1515.2000
CHAN.=  6, EARLIEST DESYNC- T= 1515.2610, V=  60844.000, LATEST SYNC- T= 1515.2620, V=  60842.000, V(1)=  60649.000, V(60)=  60874.000

BLOCK NO    9, BLOCK START TIME = 1515.3000
//// 1515.5000 BLOCK, CHANNEL  5 DROPPED BITS =   4 ////

BLOCK NO   10, BLOCK START TIME = 1515.4000
//// 1516.0000 BLOCK, CHANNEL  5 DROPPED BITS =  11 ////

BLOCK NO   11, BLOCK START TIME = 1515.5000
//// 1516.1000 BLOCK, CHANNEL  5 DROPPED BITS =   8 ////

BLOCK NO   12, BLOCK START TIME = 1516.0000
//// 1516.2000 BLOCK, CHANNEL  5 DROPPED BITS =   3 ////

BLOCK NO   13, BLOCK START TIME = 1516.1000
//// 1516.3000 BLOCK, CHANNEL  5 DROPPED BITS =   7 ////

BLOCK NO   14, BLOCK START TIME = 1516.2000
//// 1516.4000 BLOCK, CHANNEL  5 DROPPED BITS =   5 ////
```

PREVEW GAP REPORT

SURVEY 19

FIG. 14

by a symmetrical band-pass filter.

* As described in CATCH, the data are presented to the shipboard computer in digital form. Each digit 10 to 9 is presented as four binary values (bits) from 0000 to 1001. Due to the temporary malfunction of some digitizing equipment, one of the bits for a particular digit can be presented always as zero. To recover this bit, an optional routine is available that recreates this binary form for a specified digit and examines the specified bit. If the bit is zero, it is made one and the resultant data value is compared with its neighbours to see if it is closer than the original value. This process is 100% effective if the bit to be recovered is the most significant (X000) and only one digit requires recovery. As the compounding of recovery for a particular channel increases (digit and/or bit positions) the efficiency decreases, but the uncorrected values and the overcorrected values will clump together and will be detectable on the plot of the output tape (PRP). To partially overcome this limitation, the recovery of bits may optionally take place in stages, where each stage has no cognizance of any other.

This process was used on the Spring Tension trace (Fig. 13).

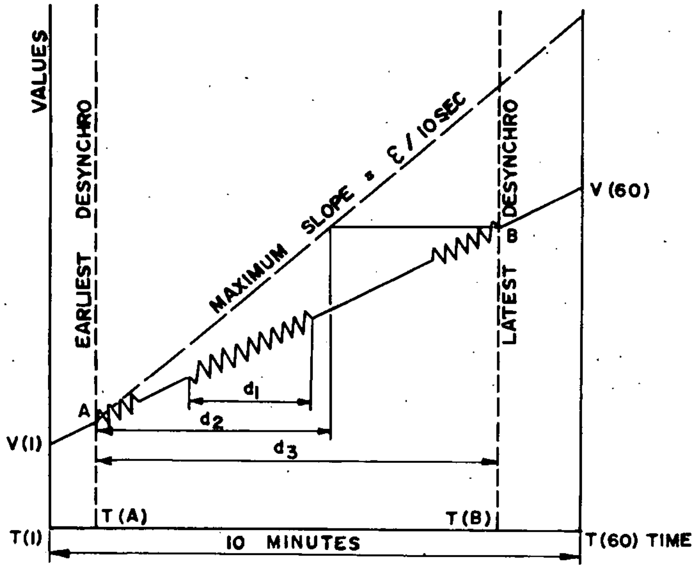
II - 2 - 2. PREVEW outputs.

The outputs from PREVEW are a printout and two tapes.

i - Print out.

* The GAP REPORT gives for each block the first time of use of $\mathcal{E}_1$ and the last time of use of $\mathcal{E}_2$, the data values of the

GAP



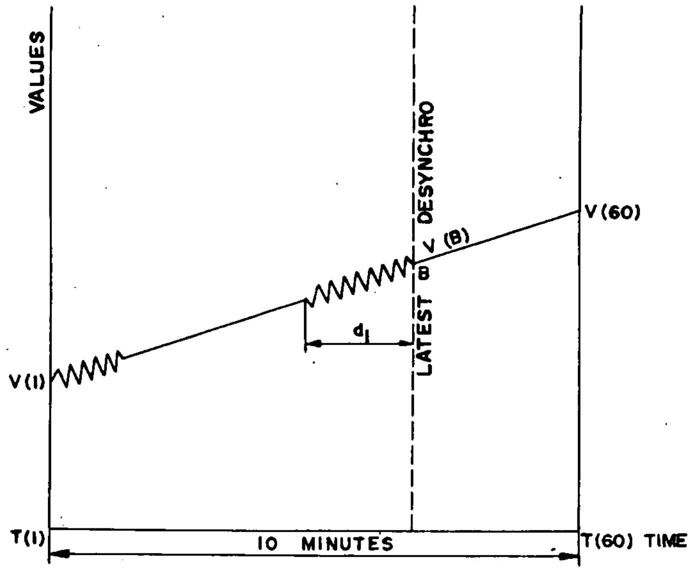
GAP REPORT

T (1) : START TIME OF BLOCK
T (A) AND V (A) : EARLIEST DESYNCHRO
T (B) AND V (B) : LATEST DESYNCHRO
V (1) : FIRST VALUE OF BLOCK
V (60) : LAST VALUE OF BLOCK

GAP MAP

3 DIGITS $d_1\, d_2\, d_3$ IN THIS ORDER
$\forall n ,\ n \leq d_i < n+1 \longrightarrow d = n .\ n \in (1, 9)$
d_1 : LONGEST DESYNCHRONISATION OF THE BLOCK
d_2 : T (B) - T (A)
d_3 : $\dfrac{V(A) - V(B)}{6\, \varepsilon_1}$ MAX. ALLOWED 9
d_1 GIVES SIZE OF LARGEST GAP
d_2 - d_3 GIVES AN APPROXIMATE INDICATION OF THE CHANGE IN THE BEHAVIOUR OF THE TRACE

END OF GAP EG



GAP REPORT

T (1) : START TIME OF BLOCK AND EARLIEST DESYNCHRO
T = 0.000
V = 0.000
T (B) AND V (B) : TIME AND VALUES OF LATEST DESYNCHRO
V (0) : LAST VALUE OF BLOCK

GAP MAP

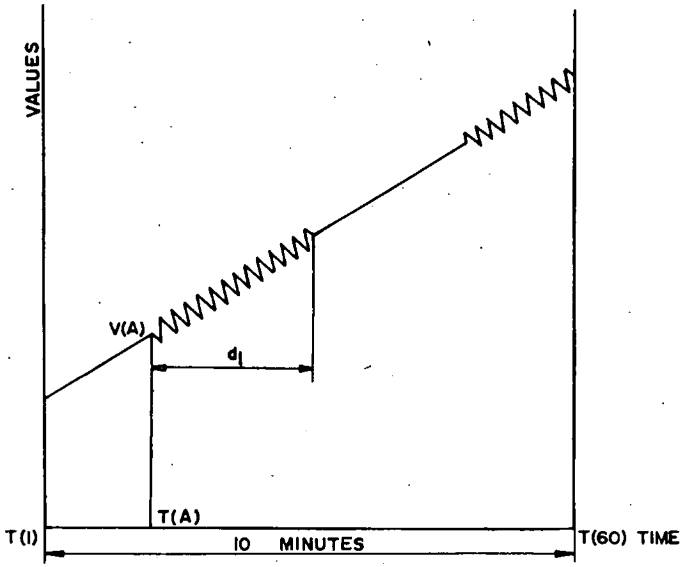
d_1 EG
d_1 : LONGEST DESYNCHRONISATION OF THE BLOCK

PREVEW GAP MAP I

WHEN A CHANGE FROM THE USE OF ε_2 TO ε_1 IS REQUIRED, WE DEFINE THAT DESYNCHRONISATION HAS OCCURRED.

FIG. 15

START OF GAP SG



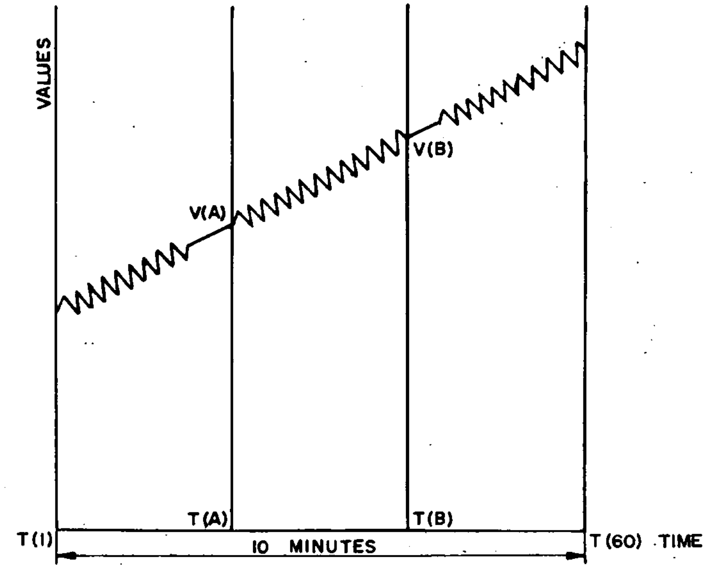
GAP REPORT

T(1) : START TIME OF BLOCK
T(A) AND V(A) : EARLIEST DESYNCHRO
LATEST DESYNCHRO
T = 0.000
V = 0.000

GAP MAP

d_1SG
d_1 : LONGEST DESYNCHRONISATION OF THE BLOCK

GAP GP



GAP REPORT

T(1) : START TIME OF BLOCK
V(1) : FIRST VALUE OF BLOCK
IF WHOLE BLOCK IS A GAP : NOTHING IS PRINTED OUT
IF WHOLE BLOCK IS NOT A GAP
T(A) AND V(A)
T(B) AND V(B)
V(60) : LAST VALUE OF BLOCK

GAP MAP

IF WHOLE BLOCK IS A GAP : 9 GP
IF WHOLE BLOCK IS NOT A GAP : d_1GP
d_1 : LONGEST DESYNCHRONISATION

PREVEW GAP MAP 2

WHEN A CHANGE FROM THE USE OF ε_2 TO ε_1 IS REQUIRED, WE DEFINE THAT DESYNCHRONISATION HAS OCCURRED.

FIG. 16

FROM 1514.10 TO 2010.50

PREVEW GAP MAP

CHANNEL 2 3

SURVEY 19

29

1	1514.10	0EG	0EG	*	0EG	0EG	0EG	0EG	0EG	0EG	*	0EG	*	*	*	*	*	*	*	*	0EG	*	*	*	*	*	*	*	0EG	*	*	*
2	1514.20	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	1514.30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	000	*	*	*
4	1514.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	1514.50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	1515.00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	1515.10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	1515.20	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	1515.30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	1515.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	1515.50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	1516.00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	1516.10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14	1516.20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15	1516.30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16	1516.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17	1516.50	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18	1517.00	*	*	*	*	*	*	*	*	*	*	001	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19	1517.10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20	1517.20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21	1517.30	*	*	*	*	*	*	*	*	*	*	040	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22	1517.40	*	*	*	*	*	*	*	*	*	*	011	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	000	*	*	*
23	1517.50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
24	1518.00	*	*	*	*	*	*	*	*	*	*	010	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
25	1518.10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
26	1518.20	*	*	*	*	*	*	*	*	*	*	011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
27	1518.30	*	*	*	*	*	*	*	*	*	*	060	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
28	1518.40	*	030	*	*	*	*	*	*	*	*	081	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
29	1518.50	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
30	1519.00	*	000	*	*	*	*	*	*	*	*	070	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
31	1519.10	*	020	*	*	*	*	*	*	*	*	004	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
32	1519.20	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
33	1519.30	*	000	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
34	1519.40	*	000	*	*	*	*	*	*	*	*	050	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
35	1519.50	*	*	*	*	*	*	220	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
36	1520.00	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
37	1520.10	*	*	*	*	*	*	000	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
38	1520.20	*	000	*	*	*	*	*	*	*	*	031	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
39	1520.30	*	000	*	*	*	*	*	*	*	*	070	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
40	1520.40	*	*	*	*	*	*	*	*	*	*	090	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
41	1520.50	*	000	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
42	1521.00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
43	1521.10	*	000	*	*	*	*	*	*	*	*	050	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
44	1521.20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
45	1521.30	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
46	1521.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
47	1521.50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
48	1522.00	*	*	*	*	*	*	*	*	*	*	060	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
49	1522.10	*	*	*	*	*	*	*	*	*	*	010	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
50	1522.20	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
51	1522.30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
52	1522.40	*	*	*	*	*	*	*	*	*	*	040	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
53	1522.50	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
54	1523.00	*	*	*	*	*	*	*	*	*	*	010	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
55	1523.10	*	*	*	*	*	*	*	*	*	*	000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
56	1523.20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
57	1523.30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
58	1523.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

FIG. 17

good points preceding and following these times respectively, plus the values of the first and last points of the block (V_1 , V_{60}). None of this information is given in the normal case, that is when all values are acceptable and $\mathcal{E}_1$ is not required. (Fig. 14).

* The GAP MAP gives an indication, in abbreviated form, of whether a switch between the use of $\mathcal{E}_1$ and $\mathcal{E}_2$ has occurred, the time of the earliest switch to $\mathcal{E}_1$ and the latest switch to $\mathcal{E}_2$, and an indication of the change in values of the trace that has occurred accross the time interval between these points. (Fig. 15 to 17).

* The SPIKE REPORT gives a count of the number of points in the block which have been corrected by the despiking procedure and the number of occasions on which a switch to the use of $\mathcal{E}_1$ occurred. (Fig 18)

* The HISTOGRAM is of quantities representative of the noise in each channel. For an accepted point, it is the difference between the predicted value and the actual value. For a bad point which has been replaced by an interpolated value, it is the difference between this interpolated value and the original value. When $\mathcal{E}_1$ is in use, none of these values are included in the histogram. (Fig. 19A and B)

ii - Tapes

* PRE tape : 10-second tape for further processing
* PRP tape : 10-second tape created for plotting purposes.

Format of these tapes is given in Appendix 1.

II - 2 - 3. PREVEW assessment.

The PREVEW reports give a list of abnormalities and gaps remaining on the output tapes; the plots obtained from the

PREVEW NOISE REPORT

FROM 1514.10 TO 2010.50

PREVEW NOISE REPORT

SURVEY 19

	CHANNEL:	2		3		4		5		6		7		8		9		10		11		12																																								
1	1514.10	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2	1514.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1514.30	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	0	0	0	0	0	0
4	1514.40	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1514.50	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1515.00	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1515.10	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1515.20	0	0	0	0	0	0	0	0	1	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1515.30	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1515.40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1515.50	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1516.00	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	1516.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1516.20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	1516.30	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	1516.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	1516.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1517.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	1517.10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	1517.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	1517.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	1517.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0
23	1517.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	1518.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	1518.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1518.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	1518.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	1518.40	0	0	2	8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	1518.50	0	0	0	0	0							0	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	1519.00	0	0	1	4	0							0	0	0	0	0	0	0	0	0	5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	1519.10	0	0	2	11	0							0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	1519.20	0	0	1	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	1519.30	0	0	1	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	1519.40	0	0	1	4	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	1519.50	0	0	0	0	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	1520.00	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	1520.10	0	0	0	0	0	0	0	0	0	0	0	0	1	11	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	1520.20	0	0	1	4	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	1520.30	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	1520.40	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	1520.50	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	1521.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	1521.10	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	1521.20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	1521.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	1521.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	1521.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	1522.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	1522.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
50	1522.20	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	1522.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	1522.40	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	1522.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	1523.00	0	1	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	1523.10	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	1523.20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	1523.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	1523.40	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	1523.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ON CH 3 :
2 desynchro.
11 bad points

FIG. 18

PRP tapes show these abnormalities and remaining gaps. The reports and the plots provide the basis for the creation of cards to correct data or fill gaps.

Six plots are produced out of the PRP tape:

1. Gravity channels: Gravity, Cross Coupling, Spring Tension and Total correction (channels 2, 3, 4, 5).

2. Navigation channels: Sonar Doppler (N/S and E/W); ch. 7 and 8.

Chernikeeff Log	Ch. 9
Pressure Log	Ch. 10
Heading	Ch. 11
Sine and Cosine of Heading	Ch. 21 and 29.
3. Depth data	Ch. 12
4. Magnetic data	Ch. 6
5. V.L.F. phases	
6. V.L.F. amplitudes.	

Due to the various kinds of corrections to be applied to the data, several methods of application were designed to be utilised by the programme MISDAT. These methods are now described.

* If large continuous amounts of data for a channel are missing then, a digitization table or strip chart digitizers are utilised to create a magnetic tape for correction in the same format as the B. cards described below. This process is further detailed in the paragraph 2 of Chapter IV, Data Digitization.

* B. Cards: block replacement card are used to replace the data for a channel in the whole of a 10- minute block. This

PREVEW HISTOGRAMME

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CHANNEL NO	1		2		3		4		5		6		7		8	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	0	0	16018	86	13505	0	0	0	9726	82	4089	0	12260	9308	13080	9471
.0010	0	0	0	0	0	0	0	0	0	0	0	0	8060	8168	7967	8022
.0020	0	0	0	0	0	0	0	0	0	0	0	0	2007	1969	1613	1608
.0039	0	0	0	0	0	0	0	0	0	0	0	0	72	57	57	48
.0078	0	0	0	0	0	0	0	0	0	0	0	0	12	9	13	10
.0156	0	0	3	2	0	0	0	0	1	1	0	0	6	6	6	9
.0313	0	0	6157	6237	0	0	0	0	5059	5040	0	0	4	4	10	8
.0625	0	0	3712	3734	0	0	0	0	4202	4184	0	0	0	0	1	0
.1250	0	0	2046	2202	1	0	0	0	3957	4471	1	0	0	0	1	0
.2500	0	0	832	688	21	10	0	0	2387	1976	6	4	1	0	1	0
.5000	0	0	144	121	7231	7473	0	0	451	383	4098	4030	0	0	0	0
1.0000	0	0	21	16	5949	5533	0	0	46	44	6523	6545	0	0	0	0
2.0000	0	0	0	1	1007	1092	0	0	9	5	5883	5834	0	0	0	0
4.0000	0	0	0	0	16	22	0	0	2	1	1565	1544	0	0	0	0
8.0000	0	0	3	0	7	1	0	0	2	0	39	42	0	0	0	0
16.0000	0	0	2	0	0	0	0	0	1	0	10	3	0	0	0	0
32.0000	0	0	0	0	3	0	0	0	0	0	7	1	0	0	0	0
64.0000	0	0	3	0	16	7	0	0	1	0	0	0	0	0	0	0
128.0000	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
256.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
512.0000	0	0	0	5	0	0	0	0	0	2	3	1	0	0	0	0
1024.0000	0	0	0	0	0	0	0	0	0	0	4	0	2	1	0	1
0.0000	0	0	0	42033	0	41894	0	0	0	42033	0	40234	0	41946	0	41927

CHANNEL NO	9		10		11		12		13		14		15		16	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	15483	10323	8108	1	0	0	1308	4	0	0	0	0	0	0	0	0
.0010	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0020	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0039	4246	3822	0	0	0	0	0	1	0	0	0	0	0	0	0	0
.0078	3990	4079	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0156	39	45	0	0	0	0	183	180	0	0	0	0	0	0	0	0
.0313	1	1	3654	12896	0	0	319	280	0	0	0	0	0	0	0	0
.0625	0	0	6460	7269	0	0	498	509	0	0	0	0	0	0	0	0
.1250	0	0	3639	5	0	0	1155	1148	0	0	0	0	0	0	0	0
.2500	0	0	0	0	0	0	2322	2335	0	0	0	0	0	0	0	0
.5000	0	0	0	0	0	0	3625	3612	0	0	0	0	0	0	0	0
1.0000	0	0	0	0	0	0	3664	3497	0	0	0	0	0	0	0	0
2.0000	0	0	0	0	0	0	2197	2051	0	0	0	0	0	0	0	0
4.0000	0	0	0	0	0	0	2023	1817	0	0	0	0	0	0	0	0
8.0000	0	0	0	0	0	0	1850	1648	0	0	0	0	0	0	0	0
16.0000	0	0	0	0	0	0	1444	1083	0	0	0	0	0	0	0	0
32.0000	0	0	0	0	0	0	412	669	0	0	0	0	0	0	0	0
64.0000	0	0	0	0	0	0	10	24	0	0	0	0	0	0	0	0
128.0000	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
256.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
512.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1024.0000	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
0.0000	0	42032	0	42032	0	0	0	39874	0	0	0	0	0	0	0	0

FIG. 19A

is analogous to the above application but applies for short intervals of data. Eleven, six or four values at regular interval are measured from the analogue records and then, when these cards are utilised to create a magnetic tape or temporary file of correction data, a spline function is used to compute the remaining ten second values of the block.

* D. Cards: block deletion cards. Will result in the data of one channel for a complete ten minute block being replaced by the value 10^{10}. The use of this card is two fold, either to delete the data and leave it deleted, usually because the ship was not surveying at this time, or to delete the data in preparation for the next type of card (P. Card).

* P. Cards: Point insertion cards can be used to correct isolated data errors at the minute points. If it is used in conjunction with the D. Card, then the effect after the programme MISDAT is similar to the B. Card but with linear as opposed to spline interpolation.

* V. Card: Volume card, is a method of defining many P. cards when creating the correction file. It has the added feature for the navigation channels (7 to 10) of enabling the automatic computation of the incremental values from integrated values.

* S. Card: Suppress card: enables the suppression of the desynchronisation indicater set by PREVEW and applies to one channel in complete ten minute blocks. Its effect is to cause all values to which 10^{10} has been added to be replaced by the original value;

* Any correction card specifying channel 11 (Heading) will, when used to create the correction file, cause the equivalent

PREVEW 1902 / 2 CONTINUATION

CHANNEL NO	17		18		19		20		21		22		23		24	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	0	0	0	0	0	0	0	0	6550	4214	0	0	0	0	0	0
.0010	0	0	0	0	0	0	0	0	1018	1008	0	0	0	0	0	0
.0020	0	0	0	0	0	0	0	0	2251	2199	0	0	0	0	0	0
.0039	0	0	0	0	0	0	0	0	2411	2552	0	0	0	0	0	0
.0078	0	0	0	0	0	0	0	0	3737	3619	0	0	0	0	0	0
.0156	0	0	0	0	0	0	0	0	3816	3807	0	0	0	0	0	0
.0313	0	0	0	0	0	0	0	0	2082	2118	0	0	0	0	0	0
.0625	0	0	0	0	0	0	0	0	275	275	0	0	0	0	0	0
.1250	0	0	0	0	0	0	0	0	3	6	0	0	0	0	0	0
.2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.5000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
256.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
512.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1024.0000	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
0.0000	0	0	0	0	0	0	0	0	0	41946	0	0	0	0	0	0

CHANNEL NO	25		26		27		28		29		30		31		32	
EXCEEDING	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG
0.0000	0	0	0	0	0	0	0	0	6152	5887	0	0	0	0	0	0
.0010	0	0	0	0	0	0	0	0	1450	1470	0	0	0	0	0	0
.0020	0	0	0	0	0	0	0	0	875	864	0	0	0	0	0	0
.0039	0	0	0	0	0	0	0	0	1002	1074	0	0	0	0	0	0
.0078	0	0	0	0	0	0	0	0	3424	3384	0	0	0	0	0	0
.0156	0	0	0	0	0	0	0	0	4894	4898	0	0	0	0	0	0
.0313	0	0	0	0	0	0	0	0	2890	2906	0	0	0	0	0	0
.0625	0	0	0	0	0	0	0	0	373	362	0	0	0	0	0	0
.1250	0	0	0	0	0	0	0	0	2	7	0	0	0	0	0	0
.2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.5000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
256.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
512.0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1024.0000	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
0.0000	0	0	0	0	0	0	0	0	0	41919	0	0	0	0	0	0

FIG. 19B

MISDAT DATA CARD FORMAT

	SURVEY NUMBER	CHANNEL NUMBER	TIME (DD HH MM)	INT		V (0) / V (6)	V (1) / V (7)	V (2) / V (8)	V (3) / V (9)	V (4) / V (10)	V (5)	
B	05	02	502040	11	1	6774.6	6775.1	6775.6	6775.6	6775.8	6776.0	INPUT BY BLOCK
C						6776.0	6776.0	6775.6	6776.0	6776.1		
B	05	04	502040	06	1	500.0	500.1	500.0	499.7	499.7	499.8	
B	05	06	520830	04	1	39978.0	39978.1	39979.0	39980.0			
D	05	05	510220	27								DELETION OF 27 BLOCKS
P	05	08	691150	04	6	0.0263	0.0261	0.0261	0.0262	0.0262	0.0261	INPUT BY POINT
P	05	07	691403	10	4	-0.0266	-0.0265	-0.0265	0.0264			
P	05	09	691520		1	0.0276						
P	05	11	641259	10	6	90.0	90.0	90.0	90.0	90.0	90.0	
V	05	07	390620	10	6	22.002	22.021	22.041	22.053	22.069	22.096	
S	05	06	551020	12								S CARD APPLIED FOR 12 BLOCKS
B	05	01	441630	11	1	1072.49997	1072.51664	1072.53330	1072.54997	1072.56664	1072.58330	TIME CORRECTION CARD
C						1072.600	1072.617	1072.633	1072.650	1072.664		

FIG. 20

correction for channels 21 and 29 (Sine and Cosine of the Heading) to be effected.

The format for all cards is shown in Fig. 20.

* Finally, the correction file will be sorted using the C.D.C. SORT MERGE programme with sort keys being: Survey, Time, Channel, and correction type in the order listed above. This sorted correction file is input to the programme MISDAT as an update file.

II - 3. MISDAT

The purpose of this programme is to incorporate data missing from the PREVEW output tape and then to ensure that the data on the MISDAT output tape is in a suitable condition for subsequent processing.

II - 3 - 1. Processing, problems encountered.

Input to the programme are the PREVEW output tapes, the sorted update file and, optionally, the time cleaned raw data tape PRP. The optional tape is used to recreate the data in Channel 10 (Pressure Log) of the PREVEW output tape before any other processing is done. This is necessary because some cruises were processed by PREVEW with thresholds (ε_1 and ε_2) that were too small.

The sorted Update file is used to correct and replace data from selected channels (including Channel 1)

MISDAT UPDATE REPORT. FROM 660800 TO 661700

CHANNELS:	1	2	3	4	5	6	7	8	9	10	11	12			15			18			21				25				29			
1	66.0800	IM	IM	G	IM	IM	IM	IM	IM	IM	M	M	*	*	*	*	*	*	*	*	IM	*	*	*	*	*	*	*	IM	*	*	*
2	66.0810	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	66.0820	*	*	*	*	*	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	66.0830	*	*	*	*	*	*	S	*	*	*	M	*	*	*	*	*	*	*	*	I	*	*	*	*	*	*	*	*	*	*	*
5	66.0840	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	66.0850	*	S	*	*	*	*	S	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	66.0900	*	S	S	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	66.0910	*	S	*	*	*	*	S	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	66.0920	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	66.0930	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	66.0940	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	66.0950	I	S	*	*	M	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	66.1000	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14	66.1010	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15	66.1020	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16	66.1030	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17	66.1040	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18	66.1050	*	*	*	*	M	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19	66.1100	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20	66.1110	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21	66.1120	*	*	*	*	*	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22	66.1130	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23	66.1140	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
24	66.1150	*	*	I	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
25	66.1200	*	*	I	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
26	66.1210	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
27	66.1220	*	*	*	*	*	IM	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
28	66.1230	*	*	*	*	*	IM	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
29	66.1240	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
30	66.1250	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
31	66.1300	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
32	66.1310	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
33	66.1320	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
34	66.1330	*	*	G	*	*	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
35	66.1340	IM	IM	G	IM	I	I	I	I	I	*	M	*	*	*	*	*	*	*	*	I	*	*	*	*	*	*	*	I	*	*	*
36	66.1350	*	*	G	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
37	66.1400	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
38	66.1410	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
39	66.1420	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
40	66.1430	*	*	I	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
41	66.1440	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
42	66.1450	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
43	66.1500	*	I	*	*	*	*	*	*	*	*	IM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
44	66.1510	*	*	*	*	*	*	*	*	*	*	IM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
45	66.1520	*	*	I	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
46	66.1530	*	I	I	*	*	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
47	66.1540	I	I	I	I	I	I	I	I	I	*	M	*	*	*	*	*	*	*	*	I	*	*	*	*	*	*	*	I	*	*	*
48	66.1550	I	I	I	I	I	I	I	I	I	*	M	*	*	*	*	*	*	*	*	I	*	*	*	*	*	*	*	I	*	*	*
49	66.1600	*	I	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
50	66.1610	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
51	66.1620	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
52	66.1630	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
53	66.1640	*	S	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
54	66.1650	*	*	*	*	*	*	*	*	I	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
55	66.1700	*	*	*	*	*	*	*	*	*	*	M	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

MISDAT REPORT SURVEY 16

FIG. 21

read from the PREVEW tape and where an Update record exists but no corresponding PREVEW record exists; then, the MISDAT output will have a record inserted. Subsequent processing in MISDAT includes the following:

* linear interpolation accross gaps less than a size specified by a parameter card, usually ten minutes.

* replacing by 1.0 E10 all data which was incorrectly converted from the field tape.

* ensuring that all data is correctly normalised to reduce the loss of accuracy in subsequent processing.

* ensuring that all values in the time channel are exact multiples of 10 seconds and are monotonic increasing.

* recomputing the heading from the final sine and cosine values.

* replacing all data out of range by 1.0 E10 exactly.

II - 3 - 2. MISDAT outputs.

A MISDAT run which includes the SORT MERGE programme produces as output four reports and two tapes, the record tape being optional

i. Printout.

* Listing of input cards, if any, and any format errors.

* MISDAT Error Report which indicates when a value from a P. Card replaces a value which PREVEW has not indicated as bad.

* MISDAT Update Report (fig. 21) shows:

- Start time of first and last block of the output tape.

ABNORMALITY REPORT

```
INPUT BLOCK      1 UPDATED FROM PRP BLOCK      1
INPUT BLOCK      2 UPDATED FROM PRP BLOCK      2
INPUT BLOCK      3 UPDATED FROM PRP BLOCK      3
INPUT BLOCK      4 UPDATED FROM PRP BLOCK      4
                        MISOUTPUT BLOCK      1 CHANNELS  00010 00000 00000 00000 00000 00000 00 WERE MADE QUASI DATA
INPUT BLOCK      5 UPDATED FROM PRP BLOCK      5
INPUT BLOCK      6 UPDATED FROM PRP BLOCK      6
INPUT BLOCK      7 UPDATED FROM PRP BLOCK      7
INPUT BLOCK      8 UPDATED FROM PRP BLOCK      8
INPUT BLOCK      9 UPDATED FROM PRP BLOCK      9
INPUT BLOCK     10 UPDATED FROM PRP BLOCK     10
INPUT BLOCK     11 UPDATED FROM PRP BLOCK     11
INPUT BLOCK     12 UPDATED FROM PRP BLOCK     12
INPUT BLOCK     13 UPDATED FROM PRP BLOCK     13
INPUT BLOCK     14 UPDATED FROM PRP BLOCK     14
INPUT BLOCK     15 UPDATED FROM PRP BLOCK     15
INPUT BLOCK     16 UPDATED FROM PRP BLOCK     16
INPUT BLOCK     17 UPDATED FROM PRP BLOCK     17
INPUT BLOCK     18 UPDATED FROM PRP BLOCK     18
INPUT BLOCK     19 UPDATED FROM PRP BLOCK     19
INPUT BLOCK     20 UPDATED FROM PRP BLOCK     20
INPUT BLOCK     21 UPDATED FROM PRP BLOCK     21
INPUT BLOCK     22 UPDATED FROM PRP BLOCK     22
INPUT BLOCK     23 UPDATED FROM PRP BLOCK     23
INPUT BLOCK     24 UPDATED FROM PRP BLOCK     24
INPUT BLOCK     25 UPDATED FROM PRP BLOCK     25
INPUT BLOCK     26 UPDATED FROM PRP BLOCK     26
INPUT BLOCK     27 UPDATED FROM PRP BLOCK     27
INPUT BLOCK     28 UPDATED FROM PRP BLOCK     28
INPUT BLOCK     29 UPDATED FROM PRP BLOCK     29
INPUT BLOCK     30 UPDATED FROM PRP BLOCK     30
INPUT BLOCK     31 UPDATED FROM PRP BLOCK     31
INPUT BLOCK     32 UPDATED FROM PRP BLOCK     32
INPUT BLOCK     33 UPDATED FROM PRP BLOCK     33
INPUT BLOCK     34 UPDATED FROM PRP BLOCK     34
INPUT BLOCK     35 UPDATED FROM PRP BLOCK     35
INPUT BLOCK     36 UPDATED FROM PRP BLOCK     36
INPUT BLOCK     37 UPDATED FROM PRP BLOCK     37
                        MISOUTPUT BLOCK     34 CHANNELS  00010 00000 00000 00000 00000 00000 00 WERE MADE QUASI DATA
INPUT BLOCK     38 UPDATED FROM PRP BLOCK     38
                        MISOUTPUT BLOCK     35 CHANNELS  00010 00000 00111 11111 01111 11101 11 WERE MADE QUASI DATA
INPUT BLOCK     39 UPDATED FROM PRP BLOCK     39
                        MISOUTPUT BLOCK     36 CHANNELS  00010 00000 00000 00000 00000 00000 00 WERE MADE QUASI DATA
INPUT BLOCK     40 UPDATED FROM PRP BLOCK     40
INPUT BLOCK     41 UPDATED FROM PRP BLOCK     41
INPUT BLOCK     42 UPDATED FROM PRP BLOCK     42
INPUT BLOCK     43 UPDATED FROM PRP BLOCK     43
INPUT BLOCK     44 UPDATED FROM PRP BLOCK     44
INPUT BLOCK     45 UPDATED FROM PRP BLOCK     45
INPUT BLOCK     46 UPDATED FROM PRP BLOCK     46
INPUT BLOCK     47 UPDATED FROM PRP BLOCK     47
INPUT BLOCK     48 UPDATED FROM PRP BLOCK     48
INPUT BLOCK     49 UPDATED FROM PRP BLOCK     49
                        MISOUTPUT BLOCK     46 CHANNELS  00000 00000 00111 11111 01111 11101 11 WERE MADE QUASI DATA
INPUT BLOCK     50 UPDATED FROM PRP BLOCK     50
                        MISOUTPUT BLOCK     47 CHANNELS  00000 00000 00111 11111 01111 11101 11 WERE MADE QUASI DATA
INPUT BLOCK     51 UPDATED FROM PRP BLOCK     51
                        MISOUTPUT BLOCK     48 CHANNELS  00000 00000 00111 11111 01111 11101 11 WERE MADE QUASI DATA
```

1,2 ——— 32

Indicate that 1.0E 10. HAS BEEN INPUT IN CHANNEL 4 OF BLOCK 4

MISDAT PRINT-OUT
Abnormality report

FIG. 22

- Gap in a block for a particular channel (G).
- Linear interpolation in a block for a particular channel (I).
- Data from Update file applied in a block for a particular channel (M).
- S Card from Update file applied to a particular channel (S).

* MISDAT Abnormality Report (fig. 22) provides:
  - list of errors in Update file
  - list of all channels in each block that have:
    - (a) been replaced by 1.0 E10 due to field tape conversion errors or because they are less than - 10^5.
    - (b) been normalised.
    - (c) been replaced by 1.0 E10 as they still retain the PREVEW desynchronisation indicator (V+1.0 E10).
  - list of time sequence errors and whether they have been corrected.
  - comparison between block numbers of PRP Plot tapes and the input tape from PREVEW.

ii. Output tapes.

* MISDAT output tape: 10-second data for further processing.
* MINIPLOT tape : 1-minute tape for quick plotting.

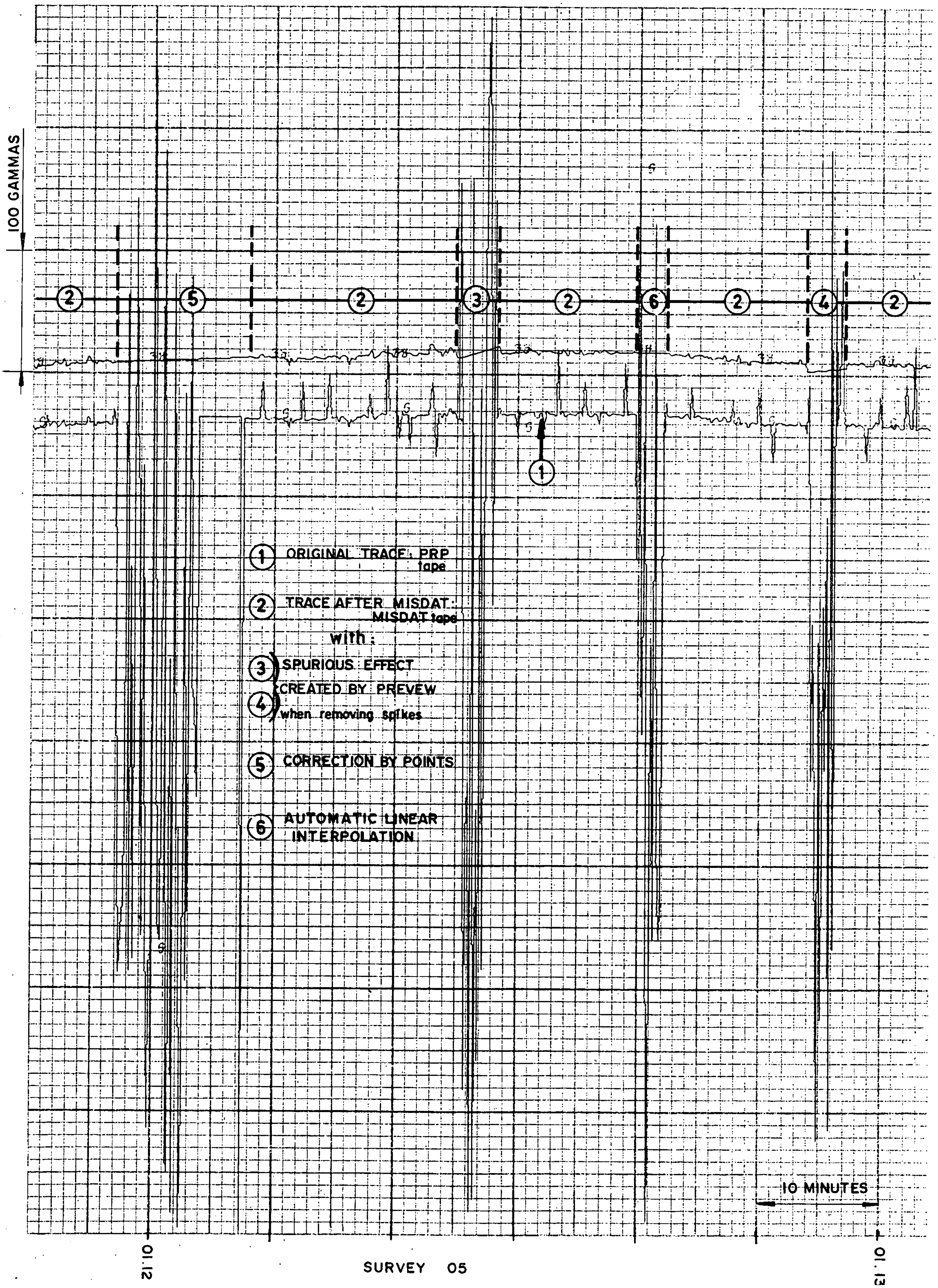
Format of these tapes is given in Appendix 1

II - 3 - 3. MISDAT assessment.

If the Print outs and the miniplot show errors remaining in the data, then, MISDAT may be run again with additional

MAGNETIC TRACE – TWO PLOT

FIG. 23



SURVEY 05

correction cards. This process applies only to Survey 05; it was abandoned when it was decided to carry out special remaining corrections on the output tape from MISDAT using further programmes which are described in the following section.

II - 4. Additional processing: CLEAN UP, TWO PLOT, EDIT.

After PREVEW and MISDAT have been performed, some problems still remain on the trace; they are:

1. Spikes: there are two possible explanations for spikes being introduced into a trace by the programme MISDAT. First there is the human error introducing a spike at the digitization table or when punching cards. Seoond, there is the fact that the use of S cards may allow spikes (unrecognized by PREVEW because of a temporary malfunction) to become visible which were disguised on the PRP plot by being a multiple of the plot scale.

2. Errors in the data missed during MISDAT assessment.

3. Spurious phenomena introduced by the programme PREVEW (Fig. 23).

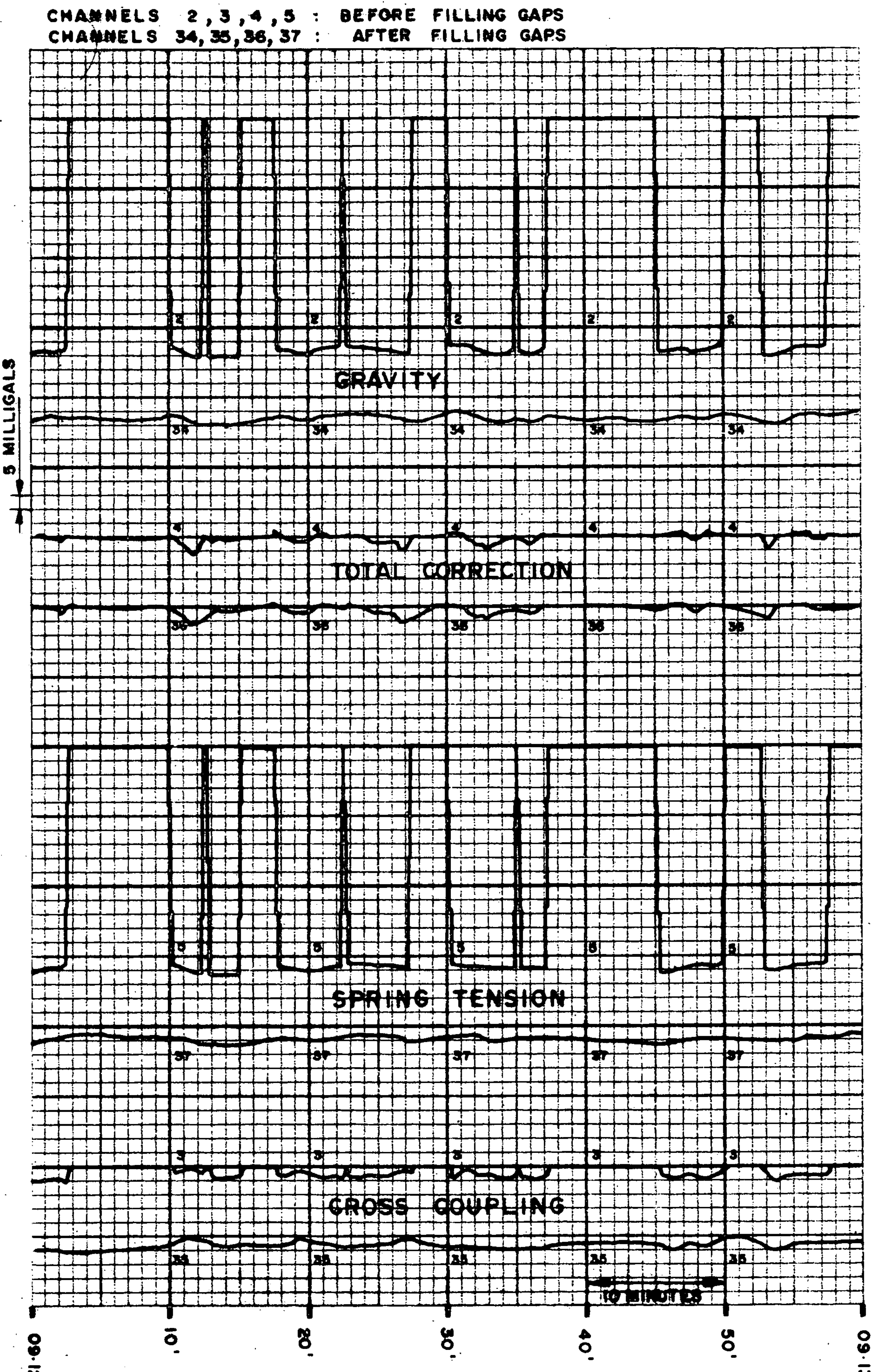
4. Unsatisfactory automatic linear interpolations

5. Due to mispunching and/or errors in reading the analogue records, wrong data were introduced into MISDAT.

One way to solve the first problem was with the BMR's programme CLEAN UP. Detailed assessment and subsequent hand corrections were carried out with the help of the BMR's plot programme: TWOPLOT. The idea behind this plot programme is to represent, on a large scale the same trace before and after processing by

FIG. 24

TWO PLOT OF GRAVITY CHANNELS



SURVEY 10

all programmes from PREVEW to CLEANUP; (example fig. 24) it utilises two tapes: the PRP plot tape and the output tape from CLEANUP.

Final editing was realised with the BMR's programme: EDIT The output tape from EDIT is the 10 second data tape which represents as nearly as possible the true values being measured by the various sensors at the time of recording. Format of this tape is given in Appendix 1.

FIG. 4
SCHEMATIC FLOW-CHART
Phase I
FIELD TAPE
CATCH
CONVERSION to CDC 3600 or 6600
CATCH OUTPUT
CATCH REPORTS
ASSESS
CARDS
PREVEW
REBLOCKING
PRE TAPE
PRP TAPE
PLOT
PREVEW REPORT
ASSESS
CARDS
DIGITIZATION TAPES
MISDAT OUTPUT
MISDAT
INPUT OF MISSING DATA
MISDAT OUTPUT
MINIPLOT
MISDAT REPORT
ASSESS
CARDS IF NECESSARY
NO CARDS
CLEANUP
CLEANUP ALL CHANNELS
CLEANUP OUTPUT
TWO PLOT
ASSESS
CORRECTIONS CARDS IF NECESSARY
EDIT
FINAL EDITION OF PHASE I TAPE
FINAL TAPE I
TO PHASE II
Phase II
OUTPUT PHASE I
GRANAV
FILTERING and GRAVITY PROCESSING
GRANAV REPORT
GRANAV PRIMARY
GRANAV GRAVITY
PLOT
EDIT CARDS
EDIT
TO CORRECT GRANAV TAPES
GRANAV CORRECTED
SATELLITES CARDS
CALNAV
CALNK + CALNA NAVIGATION CALCULATIONS FOR ASSESSMENT
CURRENT Vector
CURRENT VECTOR MAPS
CALNAV REPORT
SATELLITES CARDS
ASSESS
GRANAV CORRECTED
CALNAV
NAVIGATION CALCULATIONS
CURRENT Vector
CALNAV P.O.
CALNAV OUTPUT
EOTMAG + GRADUN
FINAL NAVIGATION FINAL GRAVITY
SHOMAG TAPE
EOTMAG OUTPUT
GRAVITY "
PLOT
GRADUN "
REPORT
GRADEUX
FORMATING BMR
REPORT
OUTPUT PHASE II

III PHASE II

The purpose of phase II is:

* To compress the information from phase I into a one - minute data tape.

* To reduce the Navigation data.

* To correct the Gravity data for Eotvos effects.

* To prepare Magnetic diurnal data for further processing.

* And finally to output a 1 minute data tape, in the appropriate format, containing the following information:

- Time
- Final positions (Latitude and Longitude).
- Depth data
- G corrected for Eotvos effects
- Magnetic data
- Magnetic shore diurnal data

The programmes of Phase II are: (fig. 4)

- GRANAV
- CALNAV
- EOTMAG - GRADED I or GRADUN
- GRADED II or GRADEUX

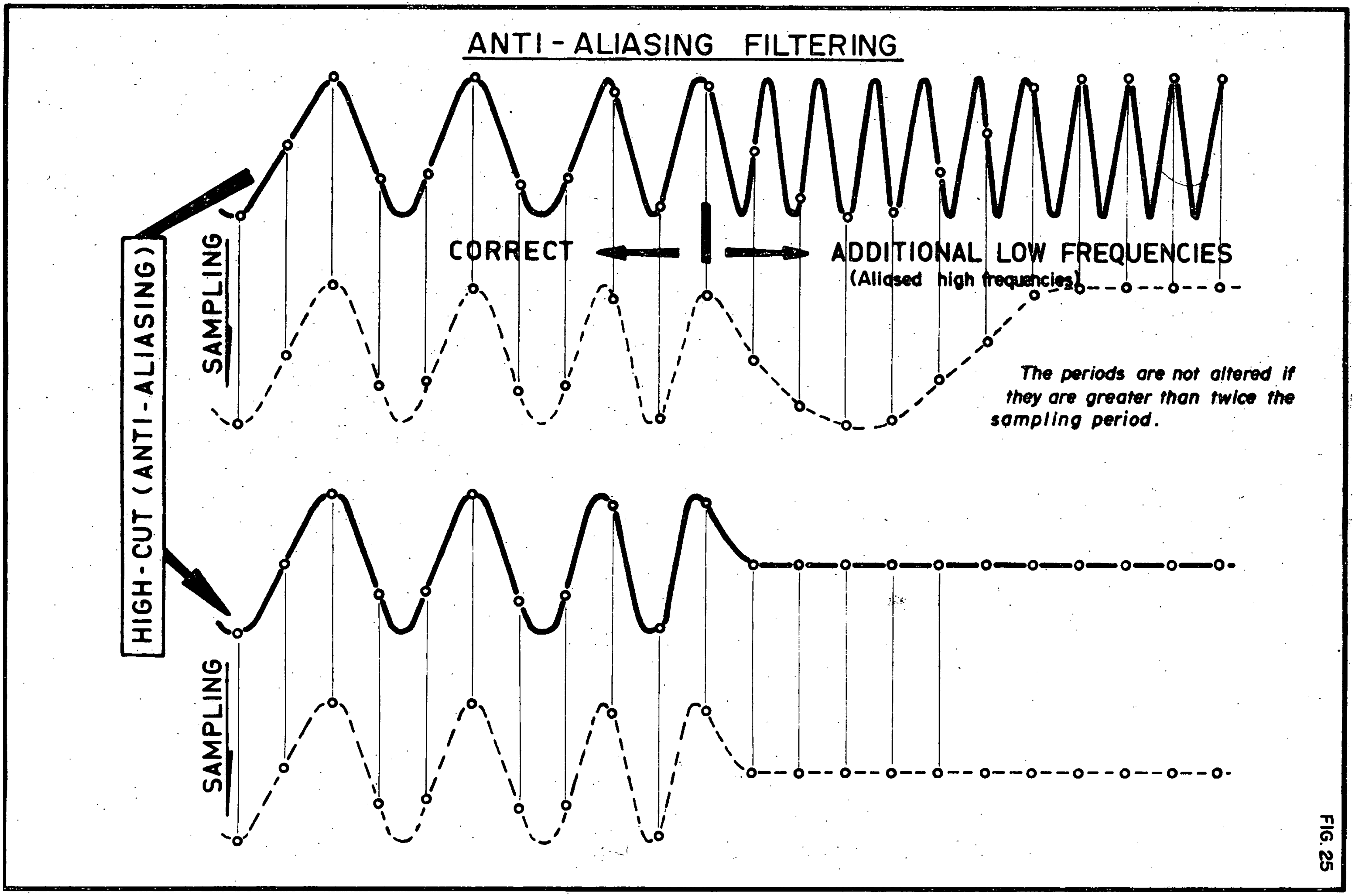

ANTI-ALIASING FILTERING
HIGH-CUT (ANTI-ALIASING)
SAMPLING
CORRECT
ADDITIONAL LOW FREQUENCIES
(Aliased high frequencies)
The periods are not altered if they are greater than twice the sampling period.
SAMPLING

FIG. 25

III - 1 - GRANAV.

The purpose of GRANAV is to sample the information from Phase I into a one minute data tape.

During the conversion, any time shifts, filtering and cross correlation necessary is carried out.

III - 1 - 1. Processing - Problems.

To perform a correct 1-minute sampling, the 2-minute periods which may be present in the spectrum of the various traces must be removed. This is realized by using an Anti aliasing (A.A) filter. (Fig. 25) which corresponds to Option I in GRANAV.

For some traces, it might not be necessary to apply an A.A. filtering before sampling. This corresponds to Option 0 on the parameter cards.

If it is thought that spikes remain on traces to which an A.A filter will be applied, then Option 3 is available: a moving median followed by a moving average are first applied to the trace with a very small window, then the A.A. filtering is performed.

Option 2 provides the average and median filters as in Option 3 but omits the A.A. filtering to enable more economical processing of non-vital channels.

Finally in Option 4, the 1 minute values are obtained by averaging over the 6 values starting at a 1-minute point.

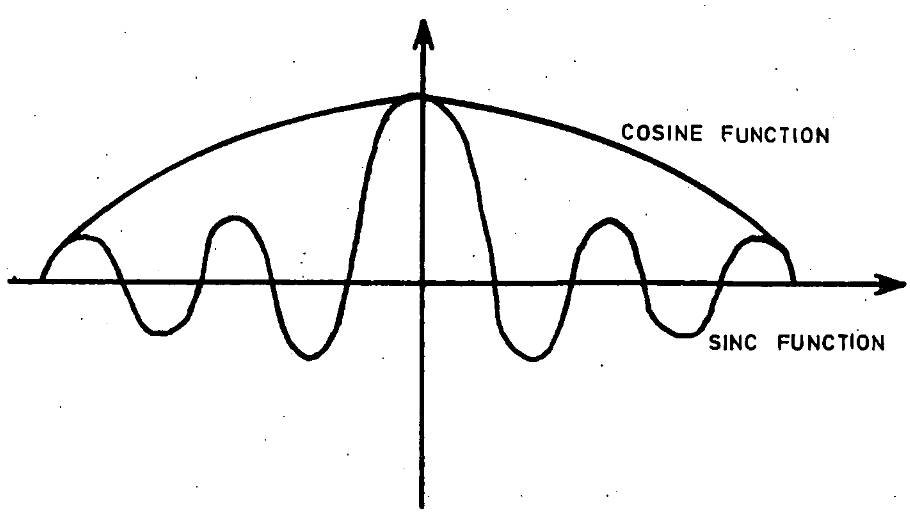
For Options 2 and 3, the size of the windows chosen in the median and averaging filters has to be specified on parameter cards.

The standard sampling processing of the two Surveys uses Option 1 for channels 2 to 10 and 21, 29. (Channel 11, the heading, is not filtered, being a discontinuous function, but Channels 21 (sine) and 29 (cosine) are filtered and the heading is recomputed from the filtered data).

With Option 1, up to five different A-A filters can be specified, but the standard processing required only two. For Channel 6 (Magnetism) the dominant period specified is 145 seconds, whereas for all other channels filtered, the dominant period is 217 seconds.

The filters used have the following common characteristics:

- all filters are sinc function filters truncated at the fifth zero crossing of the sinc function.
- all filters are multiplied by a cosine function that has its first zero crossing coincident with the fifth zero crossing of the sinc function.



FILTER PERIOD IN SECONDS 217.0

SAMPLING INTERVAL IN SECONDS 10.0

CUT-OFF AT 5.0TH ZERO

NUMBER OF POINTS IN FILTER 109

FILTER	FRACTION	PERIOD	RESPONSE
217.0	.500	108.5	.00024
217.0	.518	112.3	.00195
217.0	.536	116.3	.00189
217.0	.555	120.4	-.00036
217.0	.574	124.6	-.00302
217.0	.595	129.0	-.00359
217.0	.616	133.6	-.00087
217.0	.637	138.3	.00381
217.0	.660	143.2	.00719
217.0	.683	148.2	.00603
217.0	.707	153.4	-.00077
217.0	.732	158.9	-.01094
217.0	.758	164.5	-.01902
217.0	.785	170.3	-.01783
217.0	.812	176.3	-.00042
217.0	.841	182.5	.03806
217.0	.871	188.9	.09930
217.0	.901	195.6	.18155
217.0	.933	202.5	.28020
217.0	.966	209.6	.38880
217.0	1.000	217.0	.50029
217.0	1.035	224.7	.60806
217.0	1.072	232.6	.70673
217.0	1.110	240.8	.79257
217.0	1.149	249.3	.86358
217.0	1.189	258.1	.91933
217.0	1.231	267.2	.96063
217.0	1.275	276.6	.98915
217.0	1.320	286.3	1.00705
217.0	1.366	296.4	1.01663
217.0	1.414	306.9	1.02011
217.0	1.464	317.7	1.01947
217.0	1.516	328.9	1.01634
217.0	1.569	340.5	1.01201
217.0	1.625	352.5	1.00739
217.0	1.682	364.9	1.003[illegible]
217.0	1.741	377.8	.99952
217.0	1.803	391.1	.99680
217.0	1.866	404.9	.99496
217.0	1.932	419.2	.99395
217.0	2.000	434.0	.99365

GRANAV PRINT-OUT

ANTIALIASING FILTER USED FOR ALL CHANNELS

EXCEPT CHANNEL 6

FIG. 26

FILTER PERIOD IN SECONDS 145.0

SAMPLING INTERVAL IN SECONDS 10.0

CUT-OFF AT 5.0TH ZERO

NUMBER OF POINTS IN FILTER 73

FILTER	FRACTION	PERIOD	RESPONSE
145.0	.500	72.5	.00024
145.0	.518	75.1	.00195
145.0	.536	77.7	.00189
145.0	.555	80.4	-.00035
145.0	.574	83.3	-.00302
145.0	.595	86.2	-.00359
145.0	.616	89.3	-.00087
145.0	.637	92.4	.00381
145.0	.660	95.7	.00719
145.0	.683	99.0	.00603
145.0	.707	102.5	-.00077
145.0	.732	106.1	-.01094
145.0	.758	109.9	-.01902
145.0	.785	113.8	-.01783
145.0	.812	117.8	-.00043
145.0	.841	121.9	.03806
145.0	.871	126.2	.09930
145.0	.901	130.7	.18155
145.0	.933	135.3	.28020
145.0	.966	140.1	.38880
145.0	1.000	145.0	.50029
145.0	1.035	150.1	.60806
145.0	1.072	155.4	.70673
145.0	1.110	160.9	.79257
145.0	1.149	166.6	.86358
145.0	1.189	172.4	.91933
145.0	1.231	178.5	.96063
145.0	1.275	184.8	.98915
145.0	1.320	191.3	1.00705
145.0	1.366	198.1	1.01663
145.0	1.414	205.1	1.02011
145.0	1.464	212.3	1.01947
145.0	1.516	219.8	1.01635
145.0	1.569	227.5	1.01202
145.0	1.625	235.6	1.00740
145.0	1.682	243.9	1.00312
145.0	1.741	252.5	.99953
145.0	1.803	261.4	.99680
145.0	1.866	270.6	.99497
145.0	1.932	280.1	.99396
145.0	2.000	290.0	.99365

GRANAV PRINT-OUT

ANTIALIASING FILTER USED FOR MAGNETIC DATA (Channel 6)

FIG. 27

FIG. 28A

GRAVIMETER ZERO VALUES				
PORT	SURVEY	DAY	CALENDAR DAY	METER ZERO in mgals.
SYDNEY			13.08.70	971,161.0
MACKAY			21.08.70	971,160.8
CAIRNS			23.08.70	971,160.4
PORT MORESBY	05	00	02.09.70	971,160.1
MADANG	05	15	16.09.70	971,161.1
LAE	05	18	20.09.70	971,159.2
RABAUL	05	53	27.10.70	971,157.0
PORT MORESBY	05	78	21.11.70	971,156.7
HOBART	10	25	08.01.71	971,160.3
HOBART	10	40	20.01.71	971,161.3
EDEN	12	18	24.04.71	971,169.6
NEWCASTLE	12	26	01.15.71	971,171.2
NEWCASTLE	12	45	20.05.71	971,171.0
BRISBANE	12	65	09.06.71	971,171.1
GLADSTONE	12	87	01.07.71	971,169.9
BRISBANE	13	17	18.07.71	971,170.6
GLADSTONE	13	40	10.08.71	971,174.1
TOWNSVILLE	13	59	29.08.71	971,170.3
CAIRNS	13	79	19.09.71	971,169.5
BRISBANE	14	02	10.10.71	971,168.4
CAIRNS	14	25	02.11.71	971,168.0
CAIRNS	14	51	28.11.71	971,169.0
HOBART	14	77	24.12.71	971,169.0
LAUNCESTON	15	24	17.01.72	971,175.5
NEWCASTLE	15	76	10.03.72	971,179.1
LAUNCESTON	16	01	28.03.72	971,180.2

FIG. 28B

GRAVIMETER ZERO VALUES				
PORT	SURVEY	DAY	CALENDAR DAY	METER ZERO in mgals.
PORTLAND	16	21	18.04.72	971,178.8
PORT ADELAIDE	16	30	26.04.72	971,179.6
PORT ADELAIDE	16	51	18.05.72	971,179.4
PORT LINCOLN	16	72	08.06.72	971,178.9
ESPERANCE	17	01	03.07.72	971,180.4
FREEMANTLE	17	24	26.07.72	971,179.0
PORT HEDLAND	17	47	18.08.72	971,179.2
BROOME	17	73	13.09.72	971,186.4
BROOME	17	78	18.09.72	971,186.9
CARNARVON	18	02	27.09.72	971,185.7
DARWIN	18	18	13.10.72	971,185.6
PORT HEDLAND	18	49	13.11.72	971,184.8
FREEMANTLE	19	01	12.12.72	971,182.7
ALBANY	19	10	21.12.72	971,183.7
FREEMANTLE	19	25	06.01.73	971,183.7

The purpose of this "Hamming" function is to reduce the severity of the oscillations on the filter response curve caused by truncating the sinc function.

- All final filter coefficients are normalized by dividing each coefficient by the sum of all coefficients within the filter operator.

- The response curves of the filters used are given in Fig. 26 and 27.

The standard processing applied on the Gravity data is:

- The Gravity trace is calibrated according to the absolute value of the gravity (determined during each port of call) and calibration curves for the meter (given by the manufacturer) - See figures 28 and 35.

- The gravity channels are shifted in time to allow for delay effects of the analogue filters in the gravity meter.

This applies on Channels 2 (Gravity), 3 (Cross Coupling), 4 (Total correction). During Survey 15, the gravitymeter was overhauled in Austin (Texas). At this time the values of the different analogue filters were changed. The following table sums up the modal time shifts applied during the processing. It should be noted that the figures adopted differ substantially from the ones given by the manufacturer. One way to determine the "modal time shifts" is to do a statistical comparison between the raw Gravity trace and the raw corresponding Eotvos trace. (The time shifts are not constant: they vary with the frequency. The "Modal time Shift" is the

GRANAV INPUT DATA REPORT.
SKIP -0 READ 1800 BLOCKS.
1 INPUT TAPES AS FOLLOWS -

005709 MERGEDIT/162

ONE MINUTE SAMPLING OPTIONS-

0000000011111111112222222222333
2345678901234567890123456789012

1111111110000000000100000001000 SEE OPTION IN REPORT

OUTPUT OPTIONS - PRIMARY - ALL - VLF - PLOT
1.0000 -0.0000 -0.0000 -0.0000

TRITON PARAMETERS - 120.00000 8.00000 8.00000 4.00000 3.00000

GRAVITY ZERO 971178.800 FOR CRUISE Nº2

CORRECTIONS FOR GRAVITY	0.0	1028.2	2056.4	3084.5	4112.6	5140.7	6169.1	7197.8	8226.7	9255.5	10284.1	11311.7	12337.8
INT. FACTS.	1.0282	1.0282	1.0281	1.0281	1.0281	1.0284	1.0287	1.0289	1.0288	1.0286	1.0276	1.0261	-0.0000

GRAVITY SHIFTS. 9 5 9 CH 2 , 3 , 4 IN THIS ORDER

SAMPLING FREQUENCY 8 (hours) FOR NOISE ANALYSIS

TRITON CHANNEL 0 CROSS CORRELATION NOT DONE

FILTER HALF-WINDOWS - CH. 1-32 0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0

A-A FILTER NO - CH 1-32 02222122220000000000200000002000

NO OF LINEAR A-A FILTERS = 4

PERIODS OF CUT-OFF ARE 145 217 720 240 -0 FILTERS Nº 1,2,3,4 IN THIS ORDER

PROCESSING REPORT.

GRANAV REPORT SURVEY 16

FIG. 35

one that is considered to occur the most frequently).

Channels → / Time Periods ↓	2	3	4	COMMENTS
From Survey 05 to beginning of Survey 15	150secs	90secs	90secs	Manufacturer
	70secs	120secs	90secs	"Modal" Experimental
From end of Survey 15 to Survey 19	180secs	60secs	60secs	Manufacturer
	90secs	50secs	60secs	Experimental

For reporting purposes, a Noise Analysis is performed on Channels 2 (Gravity) and 6 (Magnetism). The main steps are as follows:

i. Given:

- a one hour block of trace and two blocks of ten minutes before and after, all data at ten second intervals,
- a filter window from B.M.R. filter programme of half window size inferior or equal to 120 points, i.e. 200 minutes, for a specified dominant period for each trace. (If for the specified dominant period, the half window size is greater than 120 points with 5 zeroes, then, less zeroes are automatically taken).
- and finally, a histogram interval.

ii. Then:

- the programme applies the filter to the block of trace to get a filtered trace in the one hour period at each ten second points.

FILTER PERIOD IN SECONDS 240.0

SAMPLING INTERVAL IN SECONDS 10.0

CUT-OFF AT .. 5.0TH ZERO

NUMBER OF POINTS IN FILTER 119

FILTER	FRACTION	PERIOD	RESPONSE
240.0	.500	120.0	.00024
240.0	.518	124.2	.00195
240.0	.536	128.6	.00189
240.0	.555	133.1	-.00036
240.0	.574	137.8	-.00302
240.0	.595	142.7	-.00359
240.0	.616	147.7	-.00087
240.0	.637	152.9	.00381
240.0	.660	158.3	.00719
240.0	.683	163.9	.00603
240.0	.707	169.7	-.00078
240.0	.732	175.7	-.01094
240.0	.758	181.9	-.01902
240.0	.785	188.3	-.01783
240.0	.812	194.9	-.00042
240.0	.841	201.8	.03806
240.0	.871	208.9	.09930
240.0	.901	216.3	.18155
240.0	.933	223.9	.28020
240.0	.966	231.8	.38879
240.0	1.000	240.0	.50028
240.0	1.035	248.5	.60805
240.0	1.072	257.2	.70673
240.0	1.110	266.3	.79257
240.0	1.149	275.7	.86358
240.0	1.189	285.4	.91933
240.0	1.231	295.5	.96063
240.0	1.275	305.9	.98915
240.0	1.320	316.7	1.00705
240.0	1.366	327.8	1.01663
240.0	1.414	339.4	1.02011
240.0	1.464	351.4	1.01947
240.0	1.516	363.8	1.01634
240.0	1.569	376.6	1.01201
240.0	1.625	389.9	1.00739
240.0	1.682	403.6	1.00311
240.0	1.741	417.9	.99952
240.0	1.803	432.6	.99679
240.0	1.866	447.9	.99496
240.0	1.932	463.6	.99395
240.0	2.000	480.0	.99365

GRANAV PRINT-OUT

FILTER USED IN NOISE ANALYSIS OF MAGNETIC DATA

FIG. 29

FILTER PERIOD IN SECONDS 720.0

SAMPLING INTERVAL IN SECONDS 10.0

CUT-OFF AT 3.0TH ZERO

NUMBER OF POINTS IN FILTER 215

FILTER	FRACTION	PERIOD	RESPONSE
720.0	.500	360.0	.00108
720.0	.518	372.7	.00442
720.0	.536	385.8	.00672
720.0	.555	399.4	.00672
720.0	.574	413.5	.00380
720.0	.595	428.1	-.00178
720.0	.616	443.2	-.00885
720.0	.637	458.8	-.01548
720.0	.660	475.0	-.01934
720.0	.683	491.8	-.01804
720.0	.707	509.1	-.00947
720.0	.732	527.1	.00793
720.0	.758	545.7	.03500
720.0	.785	564.9	.07183
720.0	.812	584.8	.11784
720.0	.841	605.4	.17184
720.0	.871	626.8	.23227
720.0	.901	648.9	.29728
720.0	.933	671.8	.36499
720.0	.966	695.5	.43355
720.0	1.000	720.0	.50127
720.0	1.035	745.4	.56672
720.0	1.072	771.7	.62872
720.0	1.110	798.9	.68641
720.0	1.149	827.1	.73918
720.0	1.189	856.2	.78669
720.0	1.231	886.4	.82882
720.0	1.275	917.7	.86564
720.0	1.320	950.0	.89735
720.0	1.366	983.5	.92426
720.0	1.414	1018.2	.94676
720.0	1.464	1054.1	.96527
720.0	1.516	1091.3	.98024
720.0	1.569	1129.8	.99210
720.0	1.625	1169.6	1.00129
720.0	1.682	1210.9	1.00821
720.0	1.741	1253.6	1.01322
720.0	1.803	1297.8	1.01665
720.0	1.866	1343.6	1.01881
720.0	1.932	1390.9	1.01994
720.0	2.000	1440.0	1.02028

GRANAV PRINT-OUT

FILTER USED IN NOISE ANALYSIS OF GRAVITY DATA

FIG. 32

NOISE ANALYSIS ON CHANNEL NO. 6 OF ONE HOUR BLOCK STARTING AT TIME 34.1300

NOISE IS THOSE FREQUENCIES OF PERIOD LESS THAN NOMINALLY 240 SECONDS.
NOISE RANGE - -3.8 TO 3.6
MEAN - -.0
VARIANCE - 1.4
R.M.S. - 1.2

NOISE HISTOGRAM -

HISTOGRAM - ONE PRINT POSITIOH = 1 PERCENT.

RANGE (OVER)	PERCENT H-GRAM	PERCENT CUM-VE	HISTOGRAM
-999.	0.0	0.0	
-40.	0.0	0.0	
-35.	0.0	0.0	
-30.	0.0	0.0	
-25.	0.0	0.0	
-20.	0.0	0.0	
-15.	0.0	0.0	
-10.	0.0	0.0	
-5.	50.6	50.6	*
0.	49.4	100.0	*
5.	0.0	100.0	
10.	0.0	100.0	
15.	0.0	100.0	
20.	0.0	100.0	
25.	0.0	100.0	
30.	0.0	100.0	
35.	0.0	100.0	
40.	0.0	100.0	
45.	0.0	100.0	
50.	0.0	100.0	

DEPTHS AT 10 MINUTE INTERVALS - 4790. 4770. 4780. 4800. 4800. 4850. METRES

SINE OF COURSE AT 10 MINUTE INTERVALS - -1.00000 -1.00000 -1.00000 -1.00000 -.99985 -1.00000

HEADING 270°

COSINE OF COURSE AT 10 MINUTE INTERVALS - -.00000 -.00000 -.00000 -.00000 .01745 -.00000

GRANAV PRINT-OUT SURVEY 16

NOISE ANALYSIS ON MAGNETIC DATA

RECORDING DONE IN DEEP WATER

FIG. 30

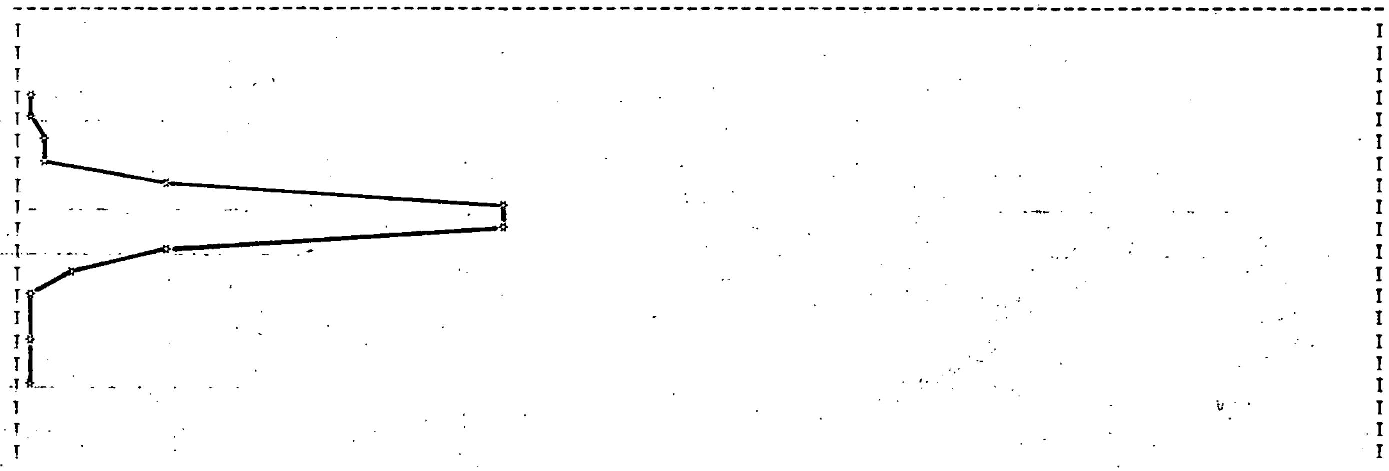
NOISE ANALYSIS ON CHANNEL NO. 6 OF ONE HOUR BLOCK STARTING AT TIME 33.2100

NOISE IS THOSE FREQUENCIES OF PERIOD LESS THAN NOMINALLY 240 SECONDS.
NOISE RANGE - -25.7 TO 35.8
MEAN - .1
VARIANCE - 44.2
R.M.S. - 6.6

NOISE HISTOGRAM -

HISTOGRAM - ONE PRINT POSITION = 1 PERCENT.

RANGE (OVER)	PERCENT H-GRAM	PERCENT CUM-VE
-999.	0.0	0.0
-40.	0.0	0.0
-35.	0.0	0.0
-30.	.6	.6
-25.	.6	1.1
-20.	1.1	2.2
-15.	1.9	4.2
-10.	10.3	14.4
-5.	35.0	49.4
0.	35.3	84.7
5.	10.0	94.7
10.	3.9	98.6
15.	.3	98.9
20.	0.0	98.9
25.	.6	99.4
30.	0.0	99.4
35.	.6	100.0
40.	0.0	100.0
45.	0.0	100.0
50.	0.0	100.0



DEPTHS AT 10 MINUTE INTERVALS - 69. 72. 71. 68. 69. 66. METRES

SINE OF COURSE AT 10 MINUTE INTERVALS - .01745 0.00000 0.00000 .01745 .01745 0.00000

COSINE OF COURSE AT 10 MINUTE INTERVALS - .99985 1.00000 1.00000 .99985 .99985 1.00000

HEADING 000

GRANAV PRINT-OUT SURVEY 16

NOISE ANALYSIS ON MAGNETIC DATA

THE SHALLOW DEPTHS INDICATE THAT THE VALUE OF THE R.M.S. COULD REPRESENT INFACT MAGNETIC PHENOMENONS ; HENCE A VISUAL INSPECTION OF THE CORRESPONDING PLOT IS NECESSARY TO AVOID ANY MISINTERPRETATION OF THE NOISE FIGURE

FIG. 31

- the filtered trace is substracted from the original trace to give a noise trace (N) in the one hour period at each ten second points (i.e. 360 values, which we call Ni, i=1,360).

- The 360 Ni values are taken as a statistical sample of the noise, and the Mean, Range, variance and Standard deviation of the Ni are determined.

- a histogram of the Ni values is drawn, showing both cumulative and interval percentages in 20 slots of the specified width.

- additional information (Depth, Heading) is printed out; this allows a better recognition of whether the values found represent the true noise figure or are due to external parameters such as change of speed or turn for gravity data, or shallow water recordings for magnetic. (See Fig 30, 31 and 33, 34).

For both Surveys, the filters used had a dominant period of 12 minutes for gravity, and 4 minutes for magnetic. Response curves are given in Fig. 29 and 32.

In a GRANAV run, all EDIT output tapes for one cruise are successively input. The GRANAV output(s) will be one tape for the whole cruise; on this tape, the time will be sequential from the first data to the last; if when reestablishing the continuity in time, data are missing, 1.0 E10 is put in each channel, except channel 1.

NOISE ANALYSIS ON CHANNEL NO. 2 OF ONE HOUR BLOCK STARTING AT TIME 34.1300

NOISE IS THOSE FREQUENCIES OF PERIOD LESS THAN NOMINALLY 720 SECONDS.
NOISE RANGE - -.8 TO .9
MEAN - .0
VARIANCE - .1
R.M.S. - .4

NOISE HISTOGRAM -

RANGE (OVER)	PERCENT H-GRAM	CUM-VE	HISTOGRAM - ONE PRINT POSITION = 1 PERCENT.
-999.	0.0	0.0	I
-16.	0.0	0.0	I
-14.	0.0	0.0	I
-12.	0.0	0.0	I
-10.	0.0	0.0	I
-8.	0.0	0.0	I
-6.	0.0	0.0	I
-4.	0.0	0.0	I
-2.	48.6	48.6	I *
0.	51.4	100.0	I *
2.	0.0	100.0	I
4.	0.0	100.0	I
6.	0.0	100.0	I
8.	0.0	100.0	I
10.	0.0	100.0	I
12.	0.0	100.0	I
14.	0.0	100.0	I
16.	0.0	100.0	I
18.	0.0	100.0	I
20.	0.0	100.0	I

DEPTHS AT 10 MINUTE INTERVALS - 4790. 4770. 4780. 4800. 4800. 4850. **METRES**

SINE OF COURSE AT 10 MINUTE INTERVALS - -1.00000 -1.00000 -1.00000 -1.00000 -.99985 -1.00000 **HEADING 270°**

COSINE OF COURSE AT 10 MINUTE INTERVALS - -.00000 -.00000 -.00000 -.00000 .01745 -.00000

GRANAV PRINT-OUT SURVEY 16

NOISE ANALYSIS ON GRAVITY DATA

FIG. 33

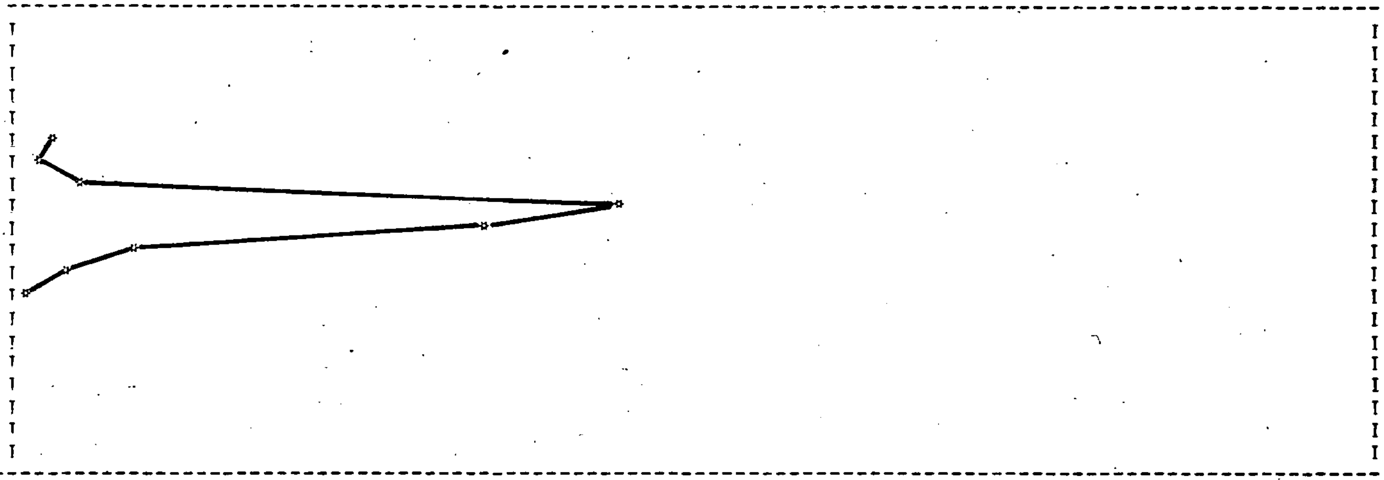
NOISE ANALYSIS ON CHANNEL NO. 2 OF ONE HOUR BLOCK STARTING AT TIME 37.0500

NOISE IS THOSE FREQUENCIES OF PERIOD LESS THAN NOMINALLY 720 SECONDS.
NOISE RANGE - -8.0 TO 6.2
MEAN - .0
VARIANCE - 4.5
R.M.S. - 2.1

NOISE HISTOGRAM -

HISTOGRAM - ONE PRINT POSITION = 1 PERCENT.

RANGE (OVER)	PERCENT H-GRAM	PERCENT CUM-VE
-999.	0.0	0.0
-16.	0.0	0.0
-14.	0.0	0.0
-12.	0.0	0.0
-10.	0.0	0.0
-8.	2.5	2.5
-6.	1.4	3.9
-4.	4.7	8.6
-2.	44.4	53.1
0.	34.4	87.5
2.	8.3	95.8
4.	3.3	99.2
6.	.8	100.0
8.	0.0	100.0
10.	0.0	100.0
12.	0.0	100.0
14.	0.0	100.0
16.	0.0	100.0
18.	0.0	100.0
20.	0.0	100.0



DEPTHS AT 10 MINUTE INTERVALS - 80. 78. 70. 58. 61. 65. METRES

SINE OF COURSE AT 10 MINUTE INTERVALS - -.03490 -.05234 -.05234 -.99985 -1.00000 -.99985

COSINE OF COURSE AT 10 MINUTE INTERVALS - .99939 .99863 .99863 .01745 -.00000 .01745

HEADING 000° 270° 270°

GRANAV PRINT-OUT SURVEY 16

NOISE ANALYSIS ON GRAVITY DATA

APPARENT NOISE IS DUE TO CHANGE OF HEADING

FIG. 34

Special optional processing: a cross - correlation may be performed between Gravity and either Cross Coupling or Total correction; (See Appendix 4 and Chapter III.3.1) If so, a 10 second data tape is output, containing high and low frequency components of the correction trace and of the Gravity minus the correction trace, Gravity trace before and after cross - correlation.
As an option, an A.A. filter may be applied to the cross correlated gravity.
(Note: The cross correlation parameters currently used are given in Appendix 4.)

III - 1 - 2. GRANAV outputs.

The outputs from GRANAV are a printout and up to four various tapes.

i. Print out.

It provides: - a list of all parameters used: gravity meter zero, options used, filters applied. (Fig. 35)

- response curves of A.A. filters (Fig. 26 and 27)

- statistical results and histograms of noise analysis, with Depths and Heading of the ship every 10 minutes during the hour of analysis. (Fig. 30,31 and 33,34).

- list of total gap time for each channel (Fig.36).

- Start and stop times for each gap in channel 7 8 or 9 (Fig. 37).

TOTAL GAP TIME IN EACH CHANNEL.

CHANNEL	GAP TIME(HRS)
2	19.2
3	17.4
4	19.9
5	19.8
6	19.4
7	17.4
8	17.4
9	17.4
10	20.0
11	16.8
12	16.8
13	17.1
14	17.1
15	17.1
16	17.1
17	17.1
18	17.1
19	17.1
20	17.1
21	17.4
22	17.1
23	17.1
24	17.1
25	17.1
26	17.1
27	17.1
28	17.1
29	17.4
30	17.1
31	17.1
32	17.1

GRANAV PRINT-OUT

TOTAL GAP TIME IN HOURS

FIG. 36

CHANNEL 7

40090000.	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	-.0126628
40091000.	-.0127146	-.0126933	-.0127640	-.0128327	-.0127425	-.0125683	-.0124583	-.0123780	-.0122490	-.0121541
40092000.	-.0122353	-.0124074	-.0125077	-.0124925	-.0123755	-.0122283	-.0121887	-.0122747	-.0123234	-.0122927
40093000.	-.0123436	-.0124729	-.0124380	-.0122598	-.0122350	-.0123700	-.0123971	-.0123212	-.0123245	-.0123191
40094000.	-.0121857	-.0121091	-.0122004	-.0122962	-.0123075	-.0123383	-.0124220	-.0124738	-.0124420	-.0123751
40095000.	-.0123653	-.0124289	-.0124445	-.0123508	-.0123176	-.0124666	-.0125844	-.0124462	-.0122275	-.0122434

CHANNEL 8

40090000.	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	.0247443
40091000.	.0246649	.0244819	.0246072	.0248382	.0248225	.0246652	.0246019	.0246165	.0246323	.0246374
40092000.	.0246368	.0246191	.0245715	.0245128	.0244643	.0243921	.0243251	.0243937	.0245689	.0246766
40093000.	.0246943	.0246924	.0246472	.0245842	.0245433	.0244521	.0243351	.0243554	.0244349	.0244157
40094000.	.0244158	.0245277	.0245835	.0245235	.0245001	.0245742	.0246703	.0247025	.0246429	.0245809
40095000.	.0246428	.0247834	.0248398	.0247911	.0247502	.0247522	.0247893	.0248801	.0249649	.0249126

CHANNEL 9

40090000.	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	*000.0000000	.0272957
40091000.	.0270608	.0269986	.0272724	.0273035	.0268814	.0266037	.0267699	.0269587	.0268853	.0268092
40092000.	.0269912	.0272610	.0273130	.0270931	.0268291	.0267013	.0267109	.0268634	.0271222	.0273100
40093000.	.0273430	.0273735	.0273738	.0270655	.0266244	.0265651	.0268304	.0269210	.0268970	.0270382
40094000.	.0270995	.0269099	.0268168	.0270340	.0272264	.0271800	.0271086	.0270928	.0270564	.0270642
40095000.	.0271065	.0270617	.0269679	.0269987	.0271617	.0272538	.0271224	.0269660	.0270044	.0271301

GRANAV PRINT-OUT

THIS REPORT GIVES AN ACCURATE DESCRIPTION OF THE REMAINING GAPS ON CHANNELS 7, 8 & 9
(SONAR DOPPLER AND CHERNIKEEFF LOG)

IT IS INTENDED TO BE USED WHEN ASSESSING THE NAVIGATION DATA.
(GAPS ARE FILLED WITH 1.0.E.10)

FIG. 37

ii. Output tapes

- Tape 20: will be used for further processing. The format is given in Appendix 1.

- Tape 25: 1-minute data tape of V.L.F. channels. It was not produced.

- Tape 30: 1-minute data tape of all channels. It was not produced.

- Tape 35: 10 second data tape of gravity traces. This tape is output when the cross - correlation is performed. The format is given in Appendix 1.

III - 1 - 3. GRANAV assessment

The GRANAV output tape 20 is plotted for assessment; channels 2 and 6 to 12 are plotted together at a small scale (1" = 1 hour) on the same plot. Navigation channels 7 to 10 are plotted in both integrated values and incremented values.

The aim of this assessment is:

- to ensure that the programme GRANAV performed correctly.

- to check that the quality of the data corresponds to the quality expected for further processing; if spurious phonomena remain (for example, error on a correction introduced in EDIT and aggravated (spread) by the A.A. filtering), they will be corrected, prior to entering CALNAV by using B.M.R.'s EDIT programme.

III - 2. CALNAV.

Purpose: Programme CALNAV reads the tape containing one-minute data for the principal channels for one cruise as produced by GRANAV, and cards containing the latitude and longitude of the satellites fixes. (See Appendix 5 for particular cases) For each of the three navigation systems (Sonar Doppler, Chernikeeff and Pressure Log) the ship's position in latitude and longitude between the fixes is determined. The output tape produced by CALNAV contains the Gravity, Magnetism and Depth data as produced by GRANAV and the latitude and longitude for each navigation system at one minute intervals.

Programme CALNAV is divided into four separate stages: CALNK, CALNA, CALNB, CALNC. First, CALNK is performed, then CALNA and finally CALNAV (which corresponds to CALNA + CALNB + CALNC).

III - 2 - 1. Processing.

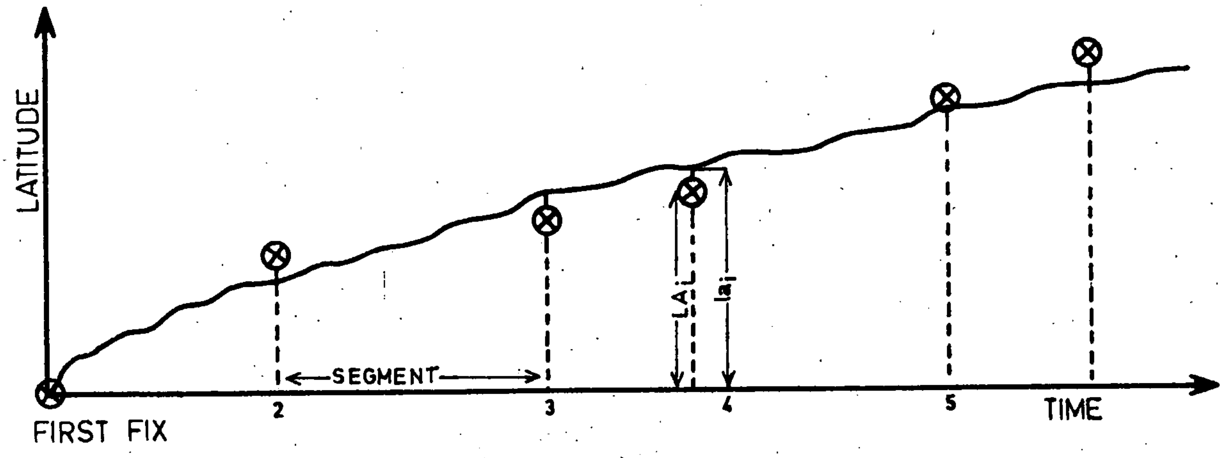
* General Processing.

i. CALNK.

CALNK reads the input tape, converts the navigation data for each system into northings and eastings, and between successive pairs of satellite fixes, calculates the calibration factors for each system. Means and standard deviations of these calibration factors are calculated and printed.

Organisation of CALNK: (for each navigation system)

1. Starting at satellite fix 1, dead reckon (d.r.) on ship navigation system to get latitude at each fix time i; let d.r. latitude be, la_i; let fix latitude be, LA_i



Note: only Latitude is shown.

2. Do same for longitude (lo_i , LO_i)

3. Calculation for each segment between consecutive fix times,

$$K_i = \frac{\text{Distance from } (la_i , lo_i) \text{ to } (la_{i+1}, lo_{i+1})}{\text{Distance from } (LA_i , LO_i) \text{ to } (LA_{i+1}, LO_{i+1})}$$

for all i where (i+1) is the consecutive fix time after i, distance being geodetic distance.

4. Averaging K_i weighted as the square of the distance from LA_i , LO_i to LA_{i+1}, LO_{i+1} .

ii. <u>CALNA</u>.

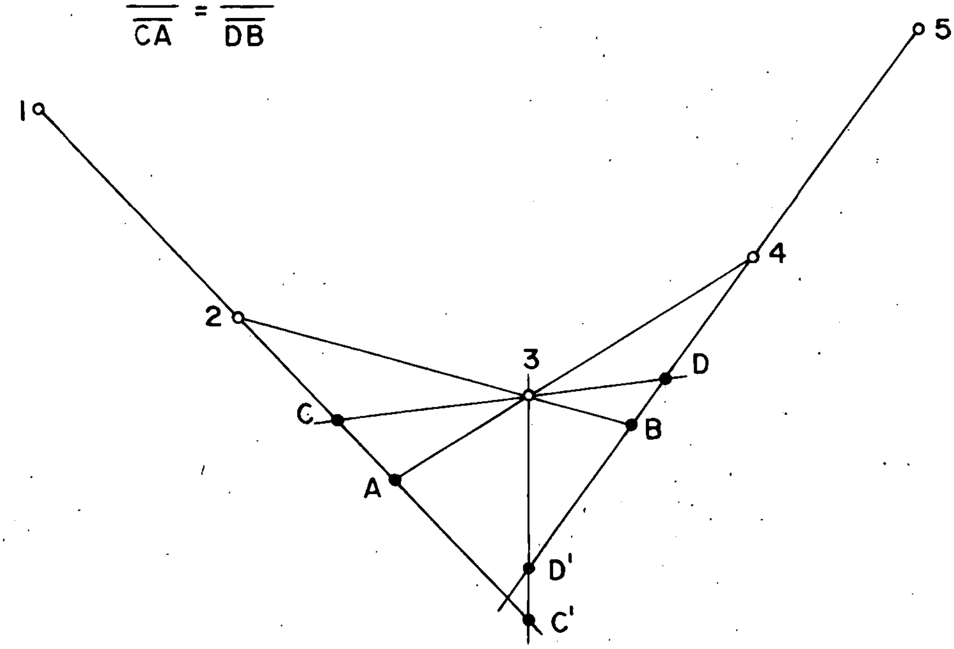
CALNA applies the mean calibration factor appropriate to each system and each time period (determined by the assessment of CALNK; for example, if one change of calibration occurs on one system at satellite Sn, it will be decided to split the calculation of the average calibration at Satellite Sn).

THE SLOPE OF THE CURVE AT POINT 3 IS DETERMINED BY:

$$t = (|m_4 - m_3| m_2 + |m_2 - m_1| m_3) / (|m_4 - m_3| + |m_2 - m_1|)$$

WHERE m_1, m_2, m_3 AND m_4 ARE THE SLOPES OF LINES $\overline{12}$, $\overline{23}$, $\overline{34}$ AND $\overline{45}$ RESPECTIVELY. UNDER THIS CONDITION THE SLOPE t OF THE CURVE AT POINT 3 DEPENDS ONLY ON THE SLOPE OF THE FOUR LINE SEGMENTS AND IS INDEPENDENT OF THE INTERVAL WIDTHS (AFTER AKIMA)

$$\frac{\overline{2C}}{\overline{CA}} = \frac{\overline{4D}}{\overline{DB}}$$



THE CURVE MUST FIT THROUGH POINTS 1, 2, 3, 4 AND 5

AKIMA CURVE FITTING METHOD

Organisation of CALNA: (for each navigation system).

Stages 1 to 4, are performed as before but taking into account the calibration splits specified by parameter cards.

5. Starting at fix 1, latitude and longitude are dead - reckoned as before but the average calibration factor(s) $\overline{K}$ is applied to the ship's observation before dead reckoning. The dead reckoned position is calculated at each 1-minute point (la'_k , lo'_k) and at each fix time (la'_i , lo'_i).

6. The error in latitude at each fix ela'_i is determined:

$$ela'_i = LA_i - la'_i$$

7. Same is done for longitude:

$$elo'_i = LO_i - lo'_i.$$

iii. CALNAV

CALNA is performed again but on the basis defined by the assessment carried out after the first run of CALNA. Then CALNB is applied:

- A Spline function is fitted through all the points ela'_i to give a value at each 1-minute point ela'_k.
- Same is done for longitude (elo'_k)
- Final latitude at each 1-minute point is determined from:

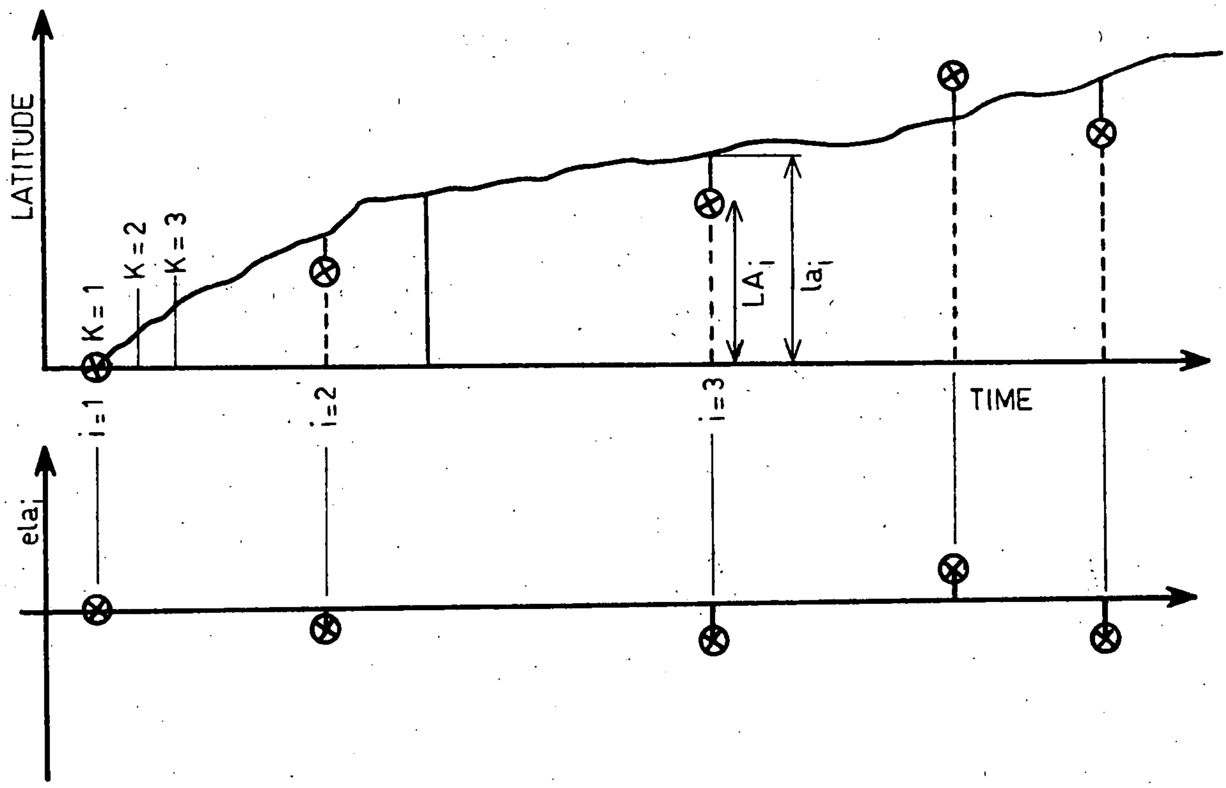
$$la_k = la'_k + ela'_k$$

- Same is done for longitude.

Remark: at each satellite fix,

$$la_k = la'_i + LA_i - la'_i$$
$$= LA_i$$

Finally, CALNC is applied: this programme reads the navigation data for the three navigation systems and combines it with the geophysical data.



* Points of special interest.

i. SPLINE functions.

Two different spline functions are incorporated in the programme CALNB: the C.G.G. spline and the AKIMA spline. The programme can use either as required.

In the first one, the curve is determined by the following means:

- between two consecutive satellite fix points, the mathematical function is a third degree polynomial curve.

- at any given satellite fix point, the curve has continuous tangent and curvature, so the Eotvos

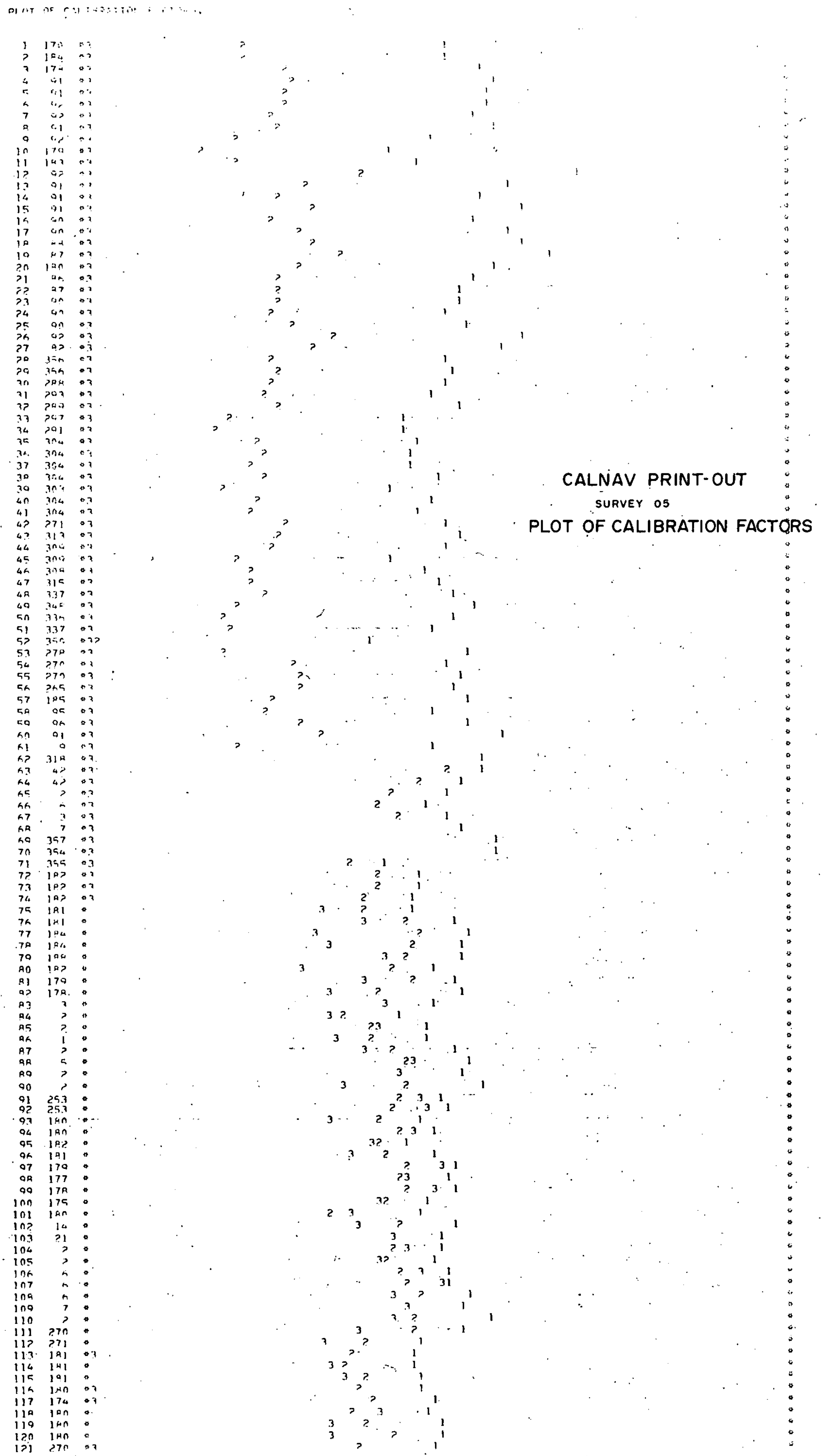


FIG. 39

CALNAV PRINT-OUT

SURVEY 05

PLOT OF CALIBRATION FACTORS

correction will be continuous and the slope of the Eotuos correction will be continuous.

- the curvature at the first three given points (and the curvature at the last three) are a linear function of the abscissas of the three points. This condition tends to prevent oscillations between successive points.

The AKIMA spline is based on a piecewise function composed of a set of polynomials, each of degree 3, at most, and applicable to successive intervals of the given points.
In this method (Fig. 38) the slope of the curve at each given point is determined from the values of the point and two neighbours each side, and each polynomial representing a portion of the curve between a pair of given points is determined by the coordinates of and the slopes at the points.
The curvature will not be continuous at the points and hence the slope of the Eotvos correction will not be continuous.
C.G.G. and AKIMA splines are written in FORTRAN language.
AKIMA spline being a special purpose subroutine takes less room in memory and appears a little faster than the other method. But the main advantage of the AKIMA is to prevent propagation of errors.

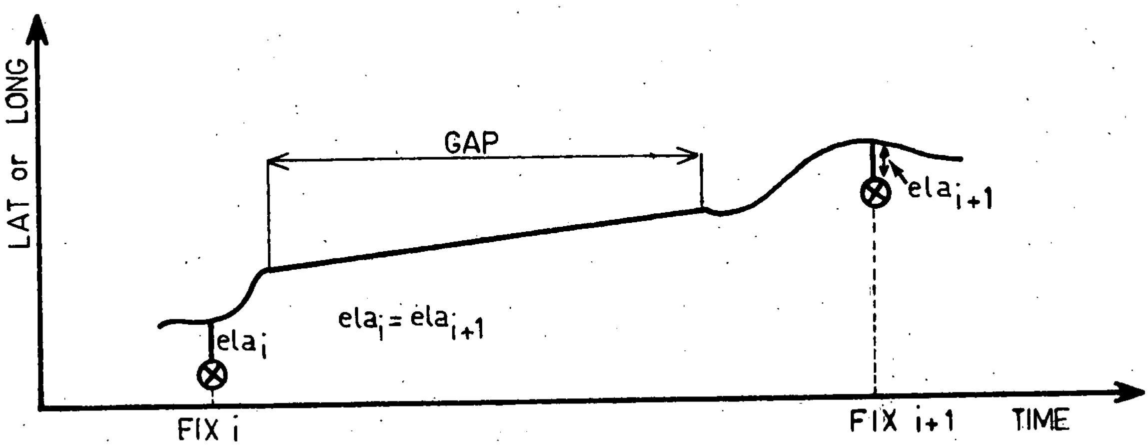
ii. <u>Calibration factors</u>. (<u>Fig. 39</u>).

Minimum and maximum thresholds for calibration factor (calculated in CALNK and CALNA) eliminate abnormal calibration factors.

iii. Gaps.

* The maximum interval acceptable by the programme CALNAV between two satellite fixes is ten hours. If a working stoppage greater than this period occurs, "dummy" satellite fix data card are input; navigation will be interpolated in straight line between each "dummy" satellite fix; this subsequent "dummy" navigation will be deleted in the following programme EOTMAG.

* If during the working period, a gap occurs in navigational data for one of the systems (due to failure or stoppage of this system), a "straight line" section is put in the gap so that the error (ela) between satellite and ship latitude is the same at fix i as at fix i+1.



In other words, the change in latitude between the fixes calculated from the ship's system is made to be the same as that calculated from the satellite.

The same is done for the longitude.

SEGMENT DETAILS					SONAR DOPPLER ERROR DETAILS					CHERNIKEF LOG ERROR DETAILS					PRESSURE LOG ERROR DET AILS.				
NO.	C	DLAT	DLON	D	LAT	LON	D	DTOT	K	LAT	LON	D	DTOT	K	LAT	LON	D	DTOT	K
151	90	-.43	25.12	24.72	-.01	1.13	1.11	23.61	.955	.25	.24	.34	24.49	.991	.26	-.20	.32	24.92	1.008
152	87	.21	21.91	21.56	.64	.20	.67	21.37	.991	1.31	-.85	1.55	22.43	1.040	1.32	-1.10	1.70	22.67	1.051
153	87	17.25	14.30	22.20	.23	-.74	.77	22.50	1.014	.04	-1.46	1.44	23.11	1.041	-.28	-1.92	1.91	23.64	1.065
154	180	2.55	-27.94	27.58	.19	.57	.59	28.13	1.020	.51	2.20	2.22	29.70	1.077	.41	2.55	2.54	30.05	1.089
155	272	-1.85	-21.85	21.55	-1.33	.04	1.32	21.52	.998	-.75	1.31	1.49	22.79	1.057	-.70	2.26	2.33	23.73	1.101
156	272	.15	-16.20	15.92	-.54	.42	.67	16.34	1.027	-.93	1.29	1.57	17.22	1.082	-.97	2.05	2.24	17.97	1.129
157	263	.52	-8.87	8.73	-.81	.31	.86	9.12	1.044	-.71	.90	1.13	9.68	1.108	-.85	2.00	2.14	10.77	1.234
158	262	.57	-15.98	15.71	-1.47	.60	1.57	16.42	1.045	-1.67	1.59	2.28	17.41	1.108	-1.70	1.81	2.45	17.63	1.122
159	262	.52	-7.64	7.53	-.29	.34	.44	7.89	1.048	-.38	.82	.89	8.37	1.111	-.40	.97	1.03	8.51	1.130
160	264	13.31	-4.07	13.83	-.18	-.55	.57	13.87	1.002	-.59	.03	.59	14.41	1.042	-.95	.18	.97	14.80	1.069
161	180	5.69	8.02	9.70	-.46	-.38	.59	10.27	1.059	-.49	-.39	.62	10.30	1.062	-.79	-.71	1.05	10.73	1.106
162	91	.71	24.37	23.93	-.27	-.31	.40	24.25	1.013	-.71	-.97	1.19	24.92	1.041	-.71	-.95	1.17	24.90	1.040
163	94	-2.38	14.42	14.36	.13	-.39	.41	14.76	1.028	-.37	-.55	.65	14.83	1.033	-.38	-.87	.94	15.15	1.055
164	0	-11.31	.55	11.27	-.13	.22	.25	11.13	.988	.17	.23	.28	11.43	1.014	.32	.23	.39	11.59	1.028
165	1	-17.50	.37	17.42	-.30	.11	.32	17.12	.982	.21	.09	.22	17.63	1.012	.50	.08	.51	17.92	1.029
166	0	-42.50	-1.22	42.32	-.96	-.48	1.07	41.35	.977	.19	-1.20	1.20	42.49	1.004	.37	-1.20	1.24	42.66	1.008
167	0	-16.92	.59	16.85	-.33	.36	.48	16.52	.980	.24	-.29	.37	17.10	1.015	.59	-.31	.66	17.45	1.036
168	4	-5.94	1.84	6.18	-.16	.53	.55	5.89	.953	.04	.25	.25	6.15	.994	-.02	.26	.26	6.10	.986
169	44	-12.23	11.32	16.52	-.39	.55	.67	15.87	.961	-.02	.82	.81	15.97	.967	.99	-.02	.98	17.27	1.045
170	36	-9.99	8.02	12.72	-.63	-.35	.71	12.46	.980	-.11	.24	.26	12.48	.982	.46	-.21	.51	13.21	1.039
171	39	-2.08	7.29	7.50	.05	-.71	.70	8.18	1.092	.15	-.59	.60	8.10	1.080	.30	-.95	.99	8.48	1.132
172	92	.28	7.30	7.22	-.02	-.69	.68	7.90	1.094	-.19	-.65	.67	7.88	1.091	-.10	1.01	1.00	0.00	0.000
173	93	.47	23.76	23.48	-.09	-1.14	1.13	24.61	1.048	-.35	-.82	.88	24.30	1.035	-.11	3.61	3.57	0.00	0.000
174	91	.74	31.62	31.25	.34	-.61	.70	31.85	1.019	.81	-.70	1.07	31.93	1.022	.57	9.10	9.01	0.00	0.000
175	87	-.54	27.06	26.75	.73	.71	1.01	26.07	.975	1.97	1.43	2.42	25.45	.952	.48	16.06	15.88	0.00	0.000

NAVIGATION SYSTEM - SONAR DOP. NO. OF REJECTED SEGMENTS - 0

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS 1.0191

MEAN OF CALIBRATION FACTOR - ACCEPTABLES 1.0191

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0399

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0399

NAVIGATION SYSTEM - CHERNIKEFF NO. OF REJECTED SEGMENTS - 4

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS 1.0213

MEAN OF CALIBRATION FACTOR - ACCEPTABLES 1.0228

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0662

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0615

NAVIGATION SYSTEM - PRESS. LOG NO. OF REJECTED SEGMENTS - 4

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS 1.0716

MEAN OF CALIBRATION FACTOR - ACCEPTABLES 1.0731

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0740

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0699

CALIBRATION SPLITS -

SONAR DOP.	1000	-0	-0	-0	-0
CHERNIKEFF	1000	-0	-0	-0	-0
PRESS. LOG	1000	-0	-0	-0	-0

CALNK PRINT-OUT

FIG. 40

III - 2 - 2. <u>CALNAV outputs</u>.

The CALNAV outputs are:

- Print outouts
- Punched cards
- Up to two magnetic tapes

i. Printouts: (all distances are in minutes of arc).

* CALNK: the printout gives the following informations:

- Listing of satellite cards.
- Details of system error, for each system

(Fig. 40):

SATELLITE

column 1 : Number of the fix.

2 : Heading of the ship at the time of the fix.

3 : On the line corresponding the satellite n, gives the change in latitude between Sat n and Sat n+1.

4 : Same for longitude

5 : On the line corresponding to Sat. n, gives the distance between Sat. n and Sat. n+1.

SYSTEM No. 1 = SONAR DOPPLER

6 : On the line corresponding to Sat. n, gives the error in Lat of the system between Sat n and Sat. n+1.

7 : Same for longitude

8 : On the line corresponding to Sat n, gives the distance between the positions determined by the system at time of Sat n and Sat n+1.

SEGMENT DETAILS					SONAR DOPPLER ERROR DETAILS					CHERNIKEFF LOG ERROR DETAILS					PRESSURE LOG ERROR DETAILS.				
NO.	C	DLAT	DLON	D	LAT	LON	D	DTOT	K	LAT	LON	D	DTOT	K	LAT	LON	D	DTOT	K
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
101	180	-17.47	-18.59	25.42	.74	-1.20	1.41	25.09	.987	-.88	-4.52	4.59	21.67	.853	.48	-4.83	4.84	22.53	.886
102	14	-21.01	4.94	21.46	.63	-.53	.82	22.21	1.034	-1.41	-1.68	2.18	20.59	.959	-2.71	-1.23	2.97	19.22	.895
103	21	-15.93	-.00	15.85	.25	-1.28	1.30	16.15	1.019	-1.03	-1.98	2.23	14.96	.944	-1.05	-1.93	2.19	14.93	.942
104	2	-12.08	-.89	12.06	.17	-.87	.89	12.20	1.012	-.67	-1.47	1.61	11.38	.943	-.43	-1.49	1.55	11.61	.963
105	2	-16.97	-.68	16.90	.11	-1.21	1.21	17.01	1.006	-1.16	-2.14	2.43	15.80	.935	-1.41	-2.11	2.53	15.55	.920
106	6	-31.09	1.49	30.97	.79	-.91	1.20	31.81	1.027	-1.54	-2.82	3.21	29.71	.959	-.91	-2.94	3.08	30.36	.980
107	6	-5.28	-.40	5.29	.17	.18	.24	5.42	1.030	-.21	-.13	.25	5.07	.962	.06	-.16	.17	5.34	1.015
108	6	-14.36	1.11	14.33	.82	.23	.85	15.13	1.056	-.34	-.81	.88	14.08	.983	-.80	-.74	1.09	13.62	.950
109	7	-22.98	1.81	22.94	1.02	1.13	1.52	23.89	1.041	-.90	-.21	.92	22.06	.962	-.81	-.20	.83	22.15	.966
110	2	-9.98	-2.25	10.18	.80	.32	.86	11.04	1.084	-.16	-.42	.45	9.95	.977	-.54	-.31	.62	9.60	.942
111	270	-.04	-14.93	14.94	.07	.67	.68	15.61	1.045	.25	-.41	.48	14.53	.972	.22	-1.51	1.52	13.44	.899
112	271	27.64	-4.62	27.89	.53	-.24	.58	27.33	.980	2.67	-.18	2.66	25.23	.905	4.42	-.73	4.46	23.43	.840
113	181	16.68	-.37	16.60	.47	-.12	.48	16.13	.972	1.96	.04	1.95	14.65	.883	2.53	.02	2.52	0.00	0.000
114	181	4.46	-.06	4.44	.13	-.00	.13	4.31	.970	.55	.05	.55	3.89	.877	.65	.05	.65	3.79	.855
115	181	21.02	-.91	20.94	.33	-.60	.68	20.59	.983	1.97	-.42	2.01	18.96	.906	2.59	-.47	2.61	18.35	.877
116	180	24.13	-2.60	24.15	.24	-2.14	2.15	23.78	.984	2.37	-2.50	3.44	21.65	.897	4.36	-2.66	5.09	0.00	0.000
117	174	37.67	1.33	37.51	-.13	-1.87	1.87	37.75	1.007	3.24	-1.70	3.65	34.39	.917	-3.95	-1.56	4.23	0.00	0.000
118	180	11.66	-.74	11.62	.06	-.67	.67	11.54	.993	1.32	-.75	1.51	10.28	.885	.81	-.75	1.10	10.79	.929
119	180	-4.24	-.22	4.22	-.07	-.20	.21	4.29	1.015	.39	-.22	.45	3.83	.906	.61	-.22	.65	3.60	.854
120	180	17.24	-6.00	18.17	-.40	-.62	.73	18.36	1.010	.82	-.69	1.06	17.18	.946	2.41	-1.06	2.62	15.56	.856
121	270	-19.71	-7.82	21.11	.04	.06	.07	21.17	1.003	-2.03	-.95	2.23	18.88	.895	-2.62	-2.76	3.79	0.00	0.000

NAVIGATION SYSTEM - SONAR DOP. NO. OF REJECTED SEGMENTS - 0

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS 1.0289

MEAN OF CALIBRATION FACTOR - ACCEPTABLES 1.0289

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0432

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0432

NAVIGATION SYSTEM - CHERNIKEFF NO. OF REJECTED SEGMENTS - 4

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS .7838 .9323

MEAN OF CALIBRATION FACTOR - ACCEPTABLES .7856 .9323

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0626 .0259

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0616 .0259

NAVIGATION SYSTEM - PRESS. LOG NO. OF REJECTED SEGMENTS - 78

MEAN OF CALIBRATION FACTOR - ALL SEGMENTS .9168

MEAN OF CALIBRATION FACTOR - ACCEPTABLES .9168

S.D. OF CALIBRATION FACTOR - ALL SEGMENTS .0416

S.D. OF CALIBRATION FACTOR - ACCEPTABLES .0416

CALIBRATION SPLITS -

SONAR DOP.	1000	-0	-0	-0	-0
CHERNIKEFF	65	1000	-0	-0	-0
PRESS. LOG	1000	-0	-0	-0	-0

REJECTED SEGMENTS: segment where in $K_i = 0$, i.e there is a gap in navigation data

ACCEPTABLE " : segment where $K_{min} < K_i < K_{max}$

ALL " : segments where there is no gap in navigation data

CALNAV PRINT-OUT Nº 1

FIG. 41

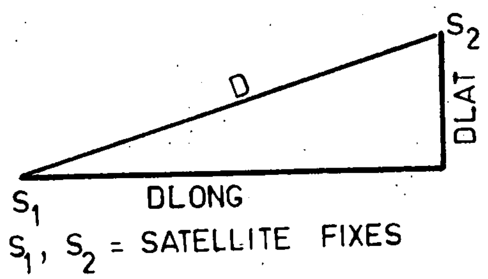
9 : On the line corresponding to Sat n, gives the distance travelled by the system between Sat n and Sat n+1.

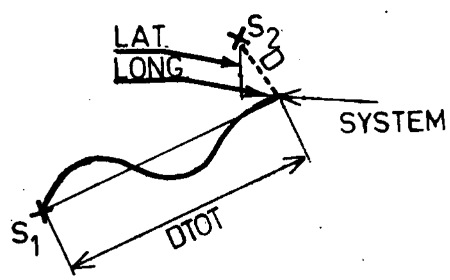
10 : Calibration coefficient $\equiv \frac{DTOT}{D}$

11 to 15 : Same as 6 to 10 for the Chernikeeff Log system.

16 to 20 : Same as 6 to 10 for the Pressure Log System.

- Mean and standard deviation of calibration factors for each system (Fig. 40).
- Rough plot of calibration factors for each system (Fig. 39).





* CALNA = The printout gives the following information:

- Listing of Satellite cards.
- Detail of system error, for each system (this information is the same as the one provided in CALNK).
- Mean and standard deviation of calibration factors for each system for each section determined by a

CALNAV PRINT-OUT Nº 2

FIX	FIX	TOT	ERROR - SYSTEM 1				ERROR - SYSTEM 2				ERROR - DYSTEM 3				MAX DIFFS			FINAL DIFFS			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
NO	TIME	PTS	LAT	LON	D	E.P	LAT	LON	D	E.P	LAT	LON	D	E.P	2-3	1-3	1-2	2-3	1-3	1-2	
101	10.0408	356	.23	-1.69	1.70	0	.33	-3.47	3.47	0	2.10	-3.33	3.93	0	.92	1.06	.73	1.78	2.48	1.77	$$$
102	10.1004	148	.03	-.37	.37	0	.01	-2.17	2.16	0	-1.06	-1.89	2.16	0	.14	.18	.10	1.11	1.86	1.79	
103	10.1232	108	-.21	-1.24	1.25	0	.05	-2.13	2.12	0	.30	-2.13	2.15	0	.20	.24	.09	.24	1.02	.92	
104	10.1420	80	-.17	-.87	.89	0	.16	-1.52	1.52	0	.63	-1.55	1.67	0	.11	.11	.01	.47	1.05	.72	
105	10.1540	112	-.37	-1.20	1.25	0	-.01	-2.25	2.24	0	-.00	-2.26	2.25	0	.28	.29	.03	.02	1.12	1.11	
106	10.1732	212	-.11	-.85	.85	0	.60	-3.14	3.19	0	1.82	-3.41	3.86	0	.42	.44	.14	1.25	3.20	2.39	
107	10.2104	36	.02	.18	.18	0	.16	-.17	.23	0	.55	-.22	.59	0	.17	.17	.01	.40	.66	.38	
108	10.2140	102	.39	.25	.47	0	.68	-.95	1.17	0	.42	-.94	1.03	0	.27	.26	.05	.26	1.19	1.24	
109	10.2322	154	.34	1.15	1.19	0	.70	-.36	.79	0	1.20	-.41	1.27	0	.51	.48	.13	.50	1.77	1.55	
110	11.0156	86	.50	.25	.56	0	.56	-.29	.63	0	.32	-.11	.34	0	.26	.30	.14	.30	.41	.54	
111	11.0322	104	.07	.23	.24	0	.27	.65	.70	0	.24	-.13	.28	0	.40	.50	.10	.79	.40	.47	
112	11.0506	214	1.29	-.36	1.34	0	.86	.14	.87	0	2.32	-.33	2.34	0	.55	.54	.11	1.53	1.03	.66	
113	11.0840	110	.92	-.13	.93	0	.89	.07	.89	0	1.25	.06	1.25	1	.35	.38	.05	.36	.38	.20	
114	11.1030	28	.25	-.00	.25	0	.27	.06	.27	0	.30	.06	.31	0	.08	.08	.01	.04	.08	.06	
115	11.1058	148	.91	-.60	1.10	0	.59	-.38	.70	0	.92	-.42	1.01	0	.48	.52	.20	.33	.18	.39	
116	11.1326	194	.91	-2.15	2.33	0	.79	-2.50	2.61	0	2.57	-2.66	3.70	1	.65	.76	.22	1.79	1.73	.37	
117	11.1640	246	.93	-1.78	2.01	0	.75	-1.93	2.06	0	.90	-1.86	2.06	3	1.04	1.10	.22	.17	.08	.23	
118	11.2046	76	.38	-.67	.77	0	.57	-.75	.94	0	-.17	-.75	.77	0	.35	.37	.02	.74	.56	.20	
119	11.2202	28	.05	-.20	.20	0	.11	-.22	.25	0	.29	-.22	.36	0	.19	.19	.01	.17	.24	.07	
120	11.2230	150	.10	-.77	.78	0	-.38	-.30	.48	0	1.07	-.53	1.19	0	.46	.28	.13	1.46	1.00	.67	
121	12.0100	190	-.51	-.17	.54	0	-.74	-.45	.87	0	-1.08	-2.21	2.45	2	1.52	1.14	.48	1.78	2.11	.36	

END OF CALNC - NO OF O/P BLCOKS = 265

FIG. 42

split if it occurs. (Fig. 41).

- A report organised as follows: (Fig. 42)

Column 1 : Number of the satellite fix.

2 : Time of the Satellite fix.

3 : On the line corresponding to Sat n, gives the time in minutes between Sat n and Sat n+1.

4 : On the line corresponding to Sat n, gives the error in latitude of the system 1 (Sonar Doppler) between Satn and Sat. n+1. after the calibration factor $\overline{K}$ has been applied.

5 : Same for longitude.

6 : On the line corresponding to Sat n, gives the distance between the position for the system at time of Sat n+1 and Sat n+1 after the calibration factor $\overline{K}$ has been applied.

7 : Number of one minute gap points for system 1 between Sat n and Sat n+1, written on the line corresponding to Sat n.

8 to 11 : identical to 4 - 7 but apply to system2: Chernikeeff Log.

12 to 15 : identical to 4 - 7 and 8 - 11 but apply to System 3: Pressure Log.

16 to 18 : On the line corresponding to Sat n give the maximum distance between the final position given by each pair of systems between Sat n and Sat n+1.

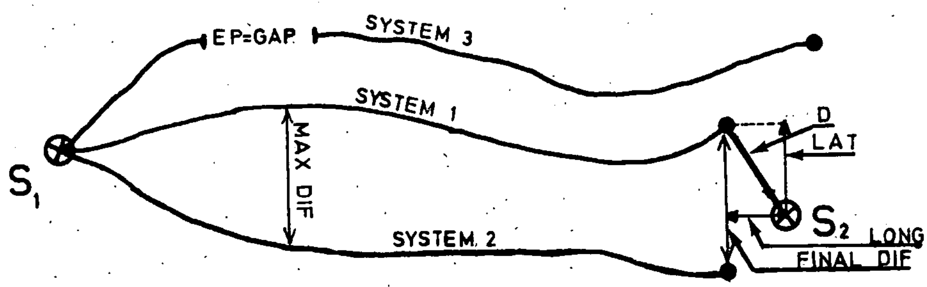
19 to 21 : On the line corresponding to Sat n, give the difference between the final position given by each pair of systems dead reckoned between Sat n and Sat n+1.

CALNAV PRINTOUT Nº 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FIX	TIME	FIX LAT	FIX LONG	DLAT	DLONG	D	CAP	CURRENT HEADINGS			CURRENT SPEEDS			DEPTH
101	100408	5.28.923	146.41.849	-17.47	-18.59	25.42	180	* 262.	265.	238. *	* .3	.6	.7*	1628.69300
102	101004	5.11.449	146.23.261	-21.01	4.94	21.48	14	* 266.	270.	299. *	* .2	.9	.9*	1618.86000
103	101232	4.50.444	146.28.199	-15.93	-.00	15.85	21	* 280.	269.	262. *	* .7	1.2	1.2*	1748.79100
104	101420	4.34.514	146.28.197	-12.08	-.89	12.06	2	* 281.	264.	248. *	* .7	1.1	1.3*	1783.90700
105	101540	4.22.431	146.27.308	-16.97	-.68	16.90	2	* 287.	270.	270. *	* .7	1.2	1.2*	1812.00000
106	101732	4. 5.460	146.26.626	-31.09	1.49	30.97	6	* 277.	259.	242. *	* .2	.9	1.1*	1359.58500
107	102104	3.34.371	146.28.117	-5.28	.40	5.26	6	* 95.	227.	202. *	* .3	.4	1.0*	2149.11600
108	102140	3.29.096	146.28.516	-14.36	1.11	14.33	6	* 147.	235.	246. *	* .3	.7	.6*	2142.09300
109	102322	3.14.735	146.29.623	-22.98	1.81	22.94	7	* 107.	207.	199. *	* .5	.3	.5*	1927.18100
110	110156	2.51.754	146.31.428	-9.98	-2.25	10.18	2	* 153.	207.	199. *	* .4	.4	.2*	827.63800
111	110322	2.41.772	146.29.180	-.04	-14.93	14.94	270	* 107.	112.	209. *	* .1	.4	.2*	848.77000
112	110506	2.41.736	146.14.249	27.64	-4.62	27.89	271	* 196.	171.	188. *	* .4	.2	.7*	760.13600
113	110840	3. 9.371	146. 9.629	16.68	-.37	16.60	181	* 188.	176.	177. *	* .5	.5	.7*	1704.58300
114	111030	3.26.046	146. 9.258	4.46	-.06	4.44	181	* 180.	168.	169. *	* .5	.6	.7*	2187.07900
115	111058	3.30.506	146. 9.196	21.02	-.91	20.94	181	* 213.	213.	205. *	* .4	.3	.4*	2172.99100
116	111326	3.51.528	146. 8.288	24.13	-2.60	24.15	180	* 247.	252.	226. *	* .7	.8	1.1*	2084.94500
117	111640	4.15.657	146. 5.690	37.67	1.33	37.51	174	* 242.	249.	244. *	* .5	.5	.5*	1820.80500
118	112046	4.53.326	146. 7.015	11.66	-.74	11.62	180	* 240.	233.	283. *	* .6	.7	.6*	670.32800
119	112202	5. 4.982	146. 6.276	4.24	-.22	4.22	180	* 255.	242.	217. *	* .4	.5	.8*	1401.70300
120	112230	5. 9.219	146. 6.057	17.24	-6.00	18.17	180	* 263,	322.	206. *	* .3	.2	.5*	1384.09300
121	120100	5.26.461	146. .053	-19.71	-7.82	21.11	270	* 342.	329.	296. *	* .2	.3	.9*	736.37200

FIG. 43

22 : contains a symbol to indicate when the Sonar Doppler, as the preferred system, is to be questioned.



- A report on the current vectors for each system: (Fig. 43).

Column 1 : Number of the satellite fix.

2 : Time of the satellite fix.

3 : Latitude of the satellite fix.

4 : Longitude of the satellite fix.

5 : On the line corresponding to Sat n, gives the change in latitude between Sat n and Sat n+1.

6 : Same for longitude.

7 : On the line corresponding to Sat n, gives the distance between Sat n and and Sat n+1.

8 : Heading of the ship at the time of the satellite fix.

9 : On the line corresponding to Sat n,

CALNAV PRINT-OUT Nº 4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FIX	FIX	TOT	ERROR - SYSTEM 1						ERROR - SYSTEM 2						ERROR - SYSTEM 3			
NO	TIME	PTS	LAT	LON	D	E.P	VLAT	VLON	LAT	LON	D	E.P	VLAT	VLON	LAT	LON	D	E.P
1	6.1220	70*	-.29	.14	.32	0	0.00	0.00*	-.32	.95	.91	0	0.00	0.00*	-.06	.46	.41	0
2	6.1330	270*	2.72	1.88	3.20	0	-41.61	19.30*	3.26	4.44	5.13	0	-46.34	135.67*	4.12	3.01	4.92	0
3	6.1800	130*	-1.11	.64	1.25	0	100.68	69.80*	-1.25	1.77	2.02	0	120.83	164.53*	-.65	1.07	1.16	0
4	6.2010	130*	-.93	.10	.93	0	-85.47	49.17*	-.72	.94	1.11	0	-96.01	136.36*	-.54	.67	.81	0
5	6.2220	60*	-.49	-.25	.54	0	-71.44	7.60*	-.27	.04	.28	0	-55.29	72.27*	-.21	-.07	.22	0
6	6.2320	10*	-.07	-.03	.08	0	-82.45	-41.67*	-.05	.02	.05	0	-45.69	7.40*	-.03	-.01	.04	0
7	6.2330	240*	2.78	5.58	5.73	218	-72.63	-32.88*	2.74	5.79	5.88	219	-49.04	16.73*	2.73	5.81	5.89	219
8	7.0330	90*	-.23	-16.43	14.77	90	115.68	232.57*	-.23	-16.43	14.77	90	114.05	241.26*	-.23	-16.43	14.77	90
9	7.0500	50*	-.99	-2.29	2.29	15	-25.67	-1825.22*	-1.13	-2.15	2.24	15	-25.67	-1825.20*	-1.02	-2.18	2.21	15
10	7.0550	50*	.66	-.65	.88	0	-198.13	-458.17*	.77	-.34	.82	0	-225.81	-430.63*	.78	-.38	.85	0
11	7.0640	50*	-.29	-.21	.35	0	131.52	-130.68*	-.26	.07	.27	0	153.24	-67.93*	-.24	.04	.24	0
12	7.0730	230*	.13	.38	.36	0	-57.76	-42.74*	.22	.72	.68	0	-51.81	14.77*	.15	.85	.78	0
13	7.1120	240*	.94	-2.04	2.06	0	5.80	16.41*	1.77	-1.64	2.31	0	9.56	31.24*	1.48	-1.10	1.78	0
14	7.1520	160*	.05	.87	.79	0	39.08	-84.94*	.69	1.70	1.68	0	73.80	-68.21*	.88	1.45	1.58	0
15	7.1800	80*	-.85	.07	.86	0	2.93	54.35*	-.48	.59	.72	0	43.10	106.13*	-.51	.63	.76	0
16	7.1920	230*	-2.96	.20	2.97	0	-106.83	8.82*	-1.74	.84	1.89	0	-59.79	73.56*	-2.15	1.49	2.54	0
17	7.2310	100*	-.67	.48	.80	0	-128.87	8.81*	.27	.55	.57	0	-75.46	36.40*	.09	.86	.79	0
18	8.0050	110*	.14	.60	.56	0	-66.56	48.43*	.98	.55	1.10	0	26.89	54.65*	.85	.77	1.10	0
19	8.0240	90*	-.49	-.22	.53	0	12.51	54.68*	.19	-.07	.20	0	89.10	49.94*	.08	.08	.11	0
20	8.0410	150*	-.29	-.19	.34	0	-54.22	-24.40*	1.05	.18	1.06	0	20.71	-7.40*	.80	.50	.92	0
21	8.0640	230*	-.25	1.01	.96	0	-19.55	-12.68*	-.22	1.29	1.20	0	69.69	11.68*	-.44	1.09	1.09	0
22	8.1030	80*	-.12	1.33	1.23	0	-10.90	44.00*	-.18	1.31	1.21	0	-9.63	56.04*	-.22	1.27	1.19	0
23	8.1150	20*	.08	.35	.33	0	-15.01	166.36*	.05	.37	.34	0	-22.37	163.52*	.04	.36	.33	0
24	8.1210	90*	-.46	.65	.75	0	39.61	175.52*	-.59	.67	.85	0	24.46	182.96*	-.28	.92	.89	0
25	8.1340	210*	1.11	2.95	2.94	0	-50.78	72.61*	.81	2.67	2.59	0	-65.53	74.69*	1.01	2.86	2.82	0
26	8.1710	80*	1.09	.44	1.16	0	52.98	140.62*	.96	.44	1.04	0	38.39	127.32*	1.02	.49	1.11	0
27	8.1830	110*	.92	-.71	1.13	0	136.21	55.29*	.55	-1.03	1.10	0	119.94	55.61*	.75	-.86	1.09	0
28	8.2020	200*	3.31	-.22	3.31	0	83.69	-64.91*	2.91	-.18	2.92	0	50.02	-93.88*	6.38	2.16	6.68	0
29	8.2340	110*	1.62	1.47	2.12	0	165.42	-11.16*	1.47	1.62	2.10	0	145.62	-8.83*	.89	1.24	1.45	0
30	9.0130	130*	2.14	2.11	2.90	0	147.09	133.59*	2.14	2.53	3.18	0	133.44	146.95*	1.43	2.01	2.35	0
31	9.0340	190*	-1.16	-.58	1.28	0	164.42	162.35*	-1.48	.71	1.62	0	164.34	194.73*	-2.42	-.08	2.42	0
32	9.0650	270*	-4.07	-.14	4.07	0	-61.07	-30.63*	-3.87	1.00	3.98	0	-77.81	37.58*	-5.20	-1.16	5.31	0
33	9.1120	100*	-.45	-.37	.56	0	-150.71	-5.14*	-.52	.10	.53	0	-143.40	37.09*	-1.04	-.76	1.25	0
34	9.1300	150*	-1.45	-.33	1.48	0	-44.88	-36.54*	-1.76	-.14	1.76	0	-52.44	9.98*	-.87	1.65	1.77	0
35	9.1530	50*	-.31	-.63	.67	0	-96.37	-22.15*	-.27	-.48	.52	0	-117.05	-9.44*	-.29	-.51	.56	0
36	9.162	60*	-.28	-.57	.60	0	-62.02	-126.14*	-.44	-.37	.56	0	-53.72	-95.32*	-.72	-.89	1.10	0
37	9.1720	50*	-.16	-.36	.37	0	-45.94	-95.60*	-.19	-.34	.37	0	-74.10	-61.92*	-.38	-.70	.76	0
38	9.1810	80*	-.09	-.71	.66	0	-31.37	-72.40*	-.21	-.53	.54	0	-38.24	-68.64*	-.53	-1.08	1.14	0
39	9.1930	210*	1.10	-3.20	3.20	0	-.24	-88.43*	1.80	-2.49	2.95	0	-26.56	-65.65*	.77	-4.05	3.88	0
40	9.2300						52.50	-152.48					85.82	-118.50				

END OF CALNAV A REVAMPED REPORTS. PLOT IS ON TAPE 9.

FIG. 44

gives the direction of the average current vector between Sat n and Sat n+1 = for Sonar Doppler.

10 : Same for Chernikeeff Log.

11 : Same for Pressure Log.

12 : On the line corresponding to Sat n, gives the average speed of the average current vector in knots between Sat n and Sat n+1: for Sonar Doppler.

13 : Same for Chernikeeff Log.

14 : Same for Pressure Log.

15 : Depth at the time of the Satellite fix.

Note: The current vector data are calculated after calibration factors $\overline{K}$ have been applied.

- A report providing: (Fig. 44).

Column 1 : Number of the Satellite fix.

2 : Time of the satellite fix.

3 : On the line corresponding to Sat n, gives the time in minutes between Sat n and Sat n+1.

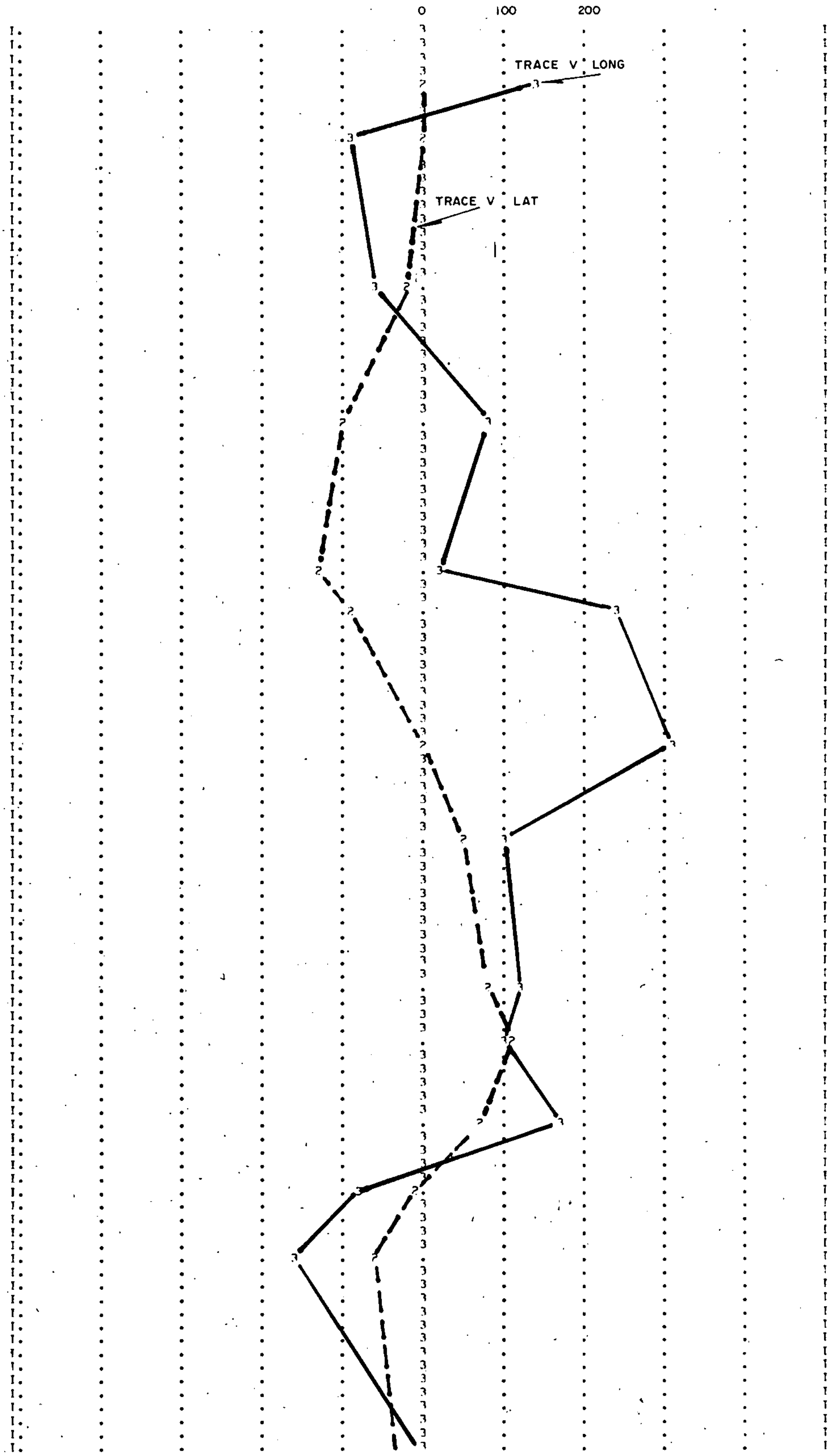
4 : On the line corresponding to Sat n, gives the error in latitude of the System 1 (Sonar Doppler) between Sat n and Sat n+1, after calibration factor $\overline{K}$ has been applied.

5 : Same for longitude.

NAVIGATION ASSESSMENT
PLOT OF THE VELOCITY ERROR VECTORS

FIG. 45

20.0430	2	0.000	3	0.000
20.0440	2	0.000	3	0.000
20.0450	2	0.000	3	0.000
20.0500	2	0.000	3	0.000
20.0510	2	4.741	3	144.586
20.0520	2	0.000	3	0.000
20.0530	2	0.000	3	0.000
20.0540	2	0.000	3	0.000
20.0550	2	.006	3	-97.042
20.0600	2	0.000	3	0.000
20.0610	2	0.000	3	0.000
20.0620	2	0.000	3	0.000
20.0630	2	0.000	3	0.000
20.0640	2	0.000	3	0.000
20.0650	2	0.000	3	0.000
20.0700	2	0.000	3	0.000
20.0710	2	0.000	3	0.000
20.0720	2	0.000	3	0.000
20.0730	2	0.000	3	0.000
20.0740	2	-29.451	3	-61.213
20.0750	2	0.000	3	0.000
20.0800	2	0.000	3	0.000
20.0810	2	0.000	3	0.000
20.0820	2	0.000	3	0.000
20.0830	2	0.000	3	0.000
20.0840	2	0.000	3	0.000
20.0850	2	0.000	3	0.000
20.0900	2	0.000	3	0.000
20.0910	2	0.000	3	0.000
20.0920	2	-109.552	3	88.820
20.0930	2	0.000	3	0.000
20.0940	2	0.000	3	0.000
20.0950	2	0.000	3	0.000
20.1000	2	0.000	3	0.000
20.1010	2	0.000	3	0.000
20.1020	2	0.000	3	0.000
20.1030	2	0.000	3	0.000
20.1040	2	0.000	3	0.000
20.1050	2	0.000	3	0.000
20.1100	2	0.000	3	0.000
20.1110	2	-132.864	3	24.524
20.1120	2	0.000	3	0.000
20.1130	2	0.000	3	0.000
20.1140	2	-93.936	3	241.867
20.1150	2	0.000	3	0.000
20.1200	2	0.000	3	0.000
20.1210	2	0.000	3	0.000
20.1220	2	0.000	3	0.000
20.1230	2	0.000	3	0.000
20.1240	2	0.000	3	0.000
20.1250	2	0.000	3	0.000
20.1300	2	0.000	3	0.000
20.1310	2	0.000	3	0.000
20.1320	2	-4.039	3	310.437
20.1330	2	0.000	3	0.000
20.1340	2	0.000	3	0.000
20.1350	2	0.000	3	0.000
20.1400	2	0.000	3	0.000
20.1410	2	0.000	3	0.000
20.1420	2	0.000	3	0.000
20.1430	2	59.537	3	104.774
20.1440	2	0.000	3	0.000
20.1450	2	0.000	3	0.000
20.1500	2	0.000	3	0.000
20.1510	2	0.000	3	0.000
20.1520	2	0.000	3	0.000
20.1530	2	0.000	3	0.000
20.1540	2	0.000	3	0.000
20.1550	2	0.000	3	0.000
20.1600	2	0.000	3	0.000
20.1610	2	0.000	3	0.000
20.1620	2	80.075	3	125.792
20.1630	2	0.000	3	0.000
20.1640	2	0.000	3	0.000
20.1650	2	0.000	3	0.000
20.1700	2	119.209	3	106.713
20.1710	2	0.000	3	0.000
20.1720	2	0.000	3	0.000
20.1730	2	0.000	3	0.000
20.1740	2	0.000	3	0.000
20.1750	2	0.000	3	0.000
20.1800	2	71.518	3	171.642
20.1810	2	0.000	3	0.000
20.1820	2	0.000	3	0.000
20.1830	2	0.000	3	0.000
20.1840	2	0.000	3	0.000
20.1850	2	-11.056	3	-89.268
20.1900	2	0.000	3	0.000
20.1910	2	0.000	3	0.000
20.1920	2	0.000	3	0.000
20.1930	2	0.000	3	0.000
20.1940	2	-65.275	3	-161.891
20.1950	2	0.000	3	0.000
20.2000	2	0.000	3	0.000
20.2010	2	0.000	3	0.000
20.2020	2	0.000	3	0.000
20.2030	2	0.000	3	0.000
20.2040	2	0.000	3	0.000
20.2050	2	0.000	3	0.000
20.2100	2	0.000	3	0.000
20.2110	2	0.000	3	0.000
20.2120	2	0.000	3	0.000
20.2130	2	0.000	3	0.000
20.2140	2	0.000	3	0.000
20.2150	2	0.000	3	0.000
20.2200	2	0.000	3	0.000



6 : On the line corresponding to Sat n, gives the distance between the system at time of Sat n and Sat n+1, after calibration factor $\overline{K}$ has been applied.

7 : No. of one minute gap points between Sat n and Sat n+1, written on the line corresponding to Sat n.

8 : "Velocity error vector" for latitude: on the line corresponding to Sat n, VLAT represents:

$$10^4 \times \frac{\text{LAT. error for system between } S_{n-1}, S_n}{T_n - T_{n-1}}$$

9 : Same for longitude

10 to 15 : Same as 4 to 9 but for the Chernikeeff Log.

16 to 19 : Same as 4 to 7 and 10 to 13 but for the Pressure Log.

The possibility exists to realise a plot of the quantities VLAT and VLONG on the line printer (fig. 45)

* CALNAV: same print outs as CALNA, but after corrections have been applied.

ii. Punched cards: either from CALNAV or CALNA. OUtput cards are punched out in order to draw current vectors map. Basically, these outputs consist of satellite fix time and location, error vectors at each satellite fix before and after coefficient calibration(s) $\overline{K}$ applied. They are used as input to the BMR programme TRAKMAP which prepares a tape for drawing current - vectors map(s) automatically on a flat bed plotter.

iii. Tapes

* Tape 9 (from CALNA or CALNAV) allows for plotting on the line printer of the velocity error vectors VLAT and VLONG.

* Tape 30 (from CALNAV): 1-minute data tape for further processing.

Format of these tapes is given in Appendix 1.

III - 2 - 3. <u>CALNAV assessment</u>.

The aim of this assessment is to eliminate suspect satellites and to evaluate the different navigation system.

i - A first assessment is carried out on the satellite computations printout. (see Chapter IV). Each satellite is examined in terms of:

- elevation, symetry of the pass, geometry of the pass.
- residuals.
- frequency.
- Sensibility to a change of .2 knots either in North speed or East speed.
- Sensibility to a change in the height of the antenna above the geoid.

This assessment enables most of the poor satellites from the input to CALNA to be eliminated.

ii. CALNK assessment: the K factors for the three systems are investigated to determine if a change of calibration occured; a rough checking of the satellite fixes is realised at the same time: if a satellite is obviously wrong and if it is not due to a mispunching of the corresponding card, it will be eliminated from the input of CALNA.

Note. when calculating the average calibration factor for each system, the statistical population is assumed to be such that the effect of the currents average out; yet, it is felt necessary to realise a calibration split on the Sonar Doppler when passing from shallow water to deep water, and the reverse.

iii. CALNA assessment.

1. Current vectors assessment method.

A. If the position given by a satellite fix is perfect except for inherent system errors, and if the only error present on the navigation data is due to the physical limitations of the dead reckoning system(Log + Compass,)then the difference between the positions given, at the same time, by the satellite fix and the dead reckoning system corresponds to the value of the surface current plus a quantity (ε) dependant on the definition of the two systems and on the presence of external parameters (e.g. wind). This applies both to the Chernikeeff Log and the Pressure Log.

B. For the Sonar Doppler there are two cases to consider:

- the Sonar Doppler tracks on the bottom. If a discrepancy is observed between the positions defined, at the same time, by a satellite fix and the Sonar Doppler, the most probable explanation is that this discrepancy represents

EFFECT OF AVERAGE CALIBRATION FACTOR ERROR ON THE HEADING OF A CURRENT VECTOR

FIG. A

GIVEN :

Vm IS THE AVERAGE SPEED GIVEN BY A DEAD RECKONING SYSTEM BETWEEN TWO SATELLITES = 10 KNOTS.

θ : ANGLE BETWEEN THE CURRENT VECTOR 1 KNOT AND Vm.

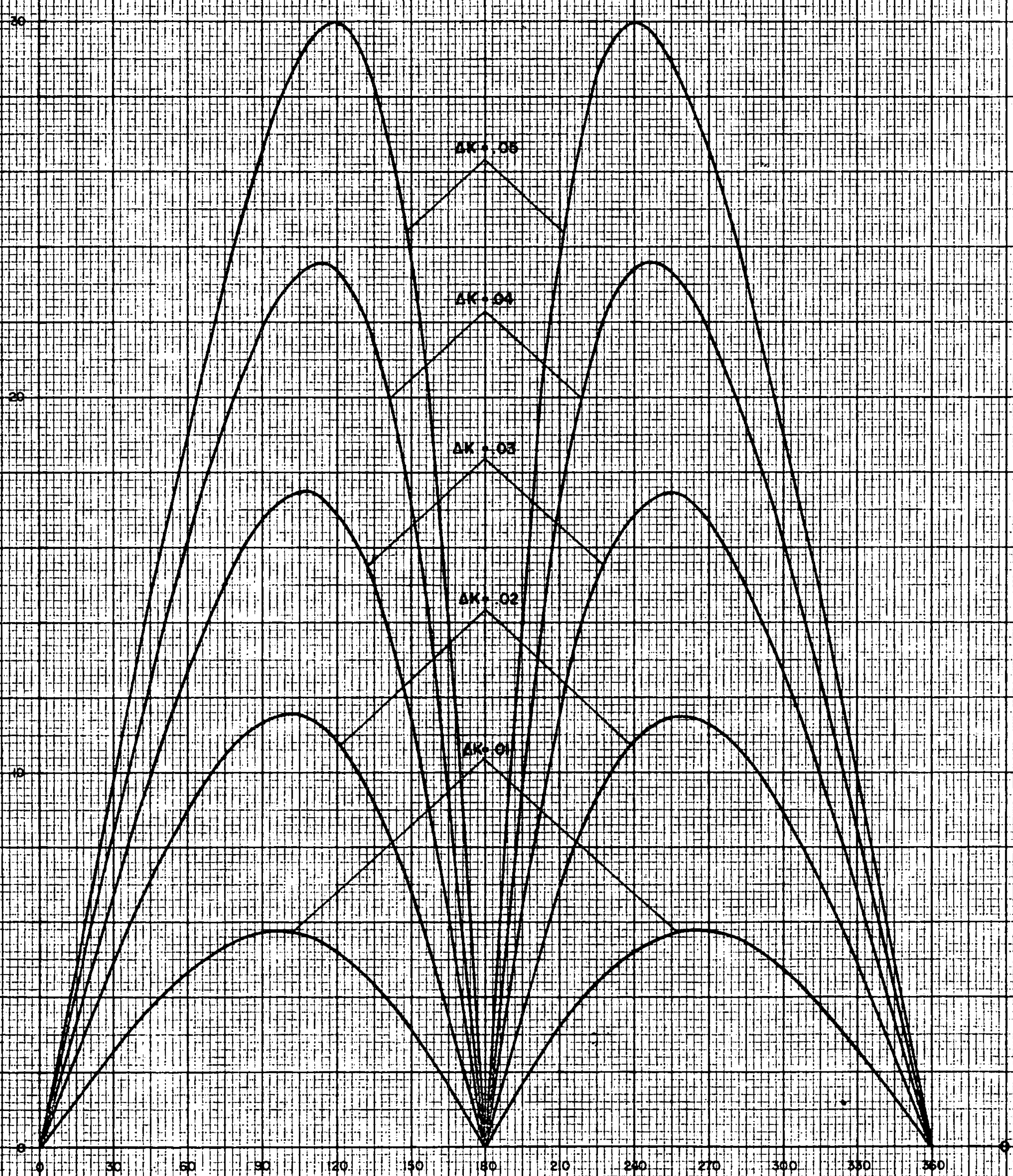
UNKNOWNS :

γ : ANGLE BETWEEN THE CURRENT VECTOR AND Vm FOR A VARIATION ΔK OF PARAMETER K.

θ − γ : ERROR ANGLE = δ

NOTE : THE ERROR CURVES ARE DRAWN FOR ΔK = .05, .04, .03, .02, .01

$$\text{tg}\,\gamma = \frac{1.\sin\theta}{10\Delta K + 1.\cos\theta}$$



the sum of the two system errors plus a possible error due to miscalibration of the Sonar Doppler.

- the Sonar Doppler tracks on the water back scatter. The discrepancy observed between the positions defined at the same time by a satellite fix and the Sonar Doppler represents the value of the current at the scattering layer depth plus the errors cited above.

From the consideration of A, and admitting a small loss in system accuracy when the Sonar Doppler tracks on the water back scatter, an assessment of the navigation may be performed based on the analysis of the discrepancies (or "error vectors") between the position of a satellite fix and the positions given by the various navigation systems at the same time as the satellite fix. Correlation can be achieved between Chernikeeff and Pressure Logs. Internal consistancy is sought within the Sonar Doppler readings when working in deep water.

Assessment: A check for consistancy in the error vectors for each system is carried out on the printouts numbered 2 and 3. This "local" assessment must be completed by a "spatial" assessment made with the current vector map which allows a correlation of the current vectors from line to line hence avoiding the rejection of a satellite which gives a current not consistant with the others on the same line.

FIG. 8

EFFECT OF AN ERROR IN THE SATELLITE FIX LONGITUDE ON THE HEADING OF A CURRENT VECTOR

GIVEN A 1 KNOT CURRENT VECTOR, HEADING θ, CALCULATED BETWEEN SATELLITE FIXES S_1 AND S_2 SUPPOSED PERFECT (θ MEASURED FROM THE LONGITUDE AXIS). THEN, IF AN ERROR IS INTRODUCED ON THE LONGITUDES OF BOTH S_1 AND S_2, WHAT WILL BE THE EFFECT ON θ ?

LET 175 m BE THE LONGITUDE ERROR FOR EACH SATELLITE ; 350 m IS THE MAXIMUM ERROR ≡ .188 MILE AND :-

$\frac{.188 \times 60}{\Delta T}$ KNOTS, WHEN SATELLITES ARE ΔT MINUTES APART, IS THE AMPLITUDE OF THE ERROR VECTOR INTRODUCED.

LET γ BE THE NEW HEADING OF THE CURRENT VECTOR AFTER VECTOR ERROR HAS BEEN INTRODUCED.

THEREFORE $\delta = \theta - \gamma$ IS THE RESULTING ERROR.

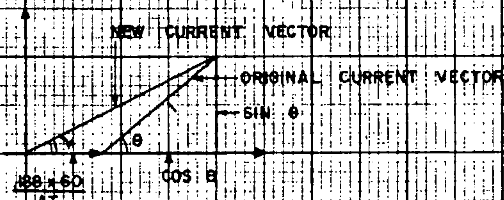
THE GENERAL FORMULA IS :-

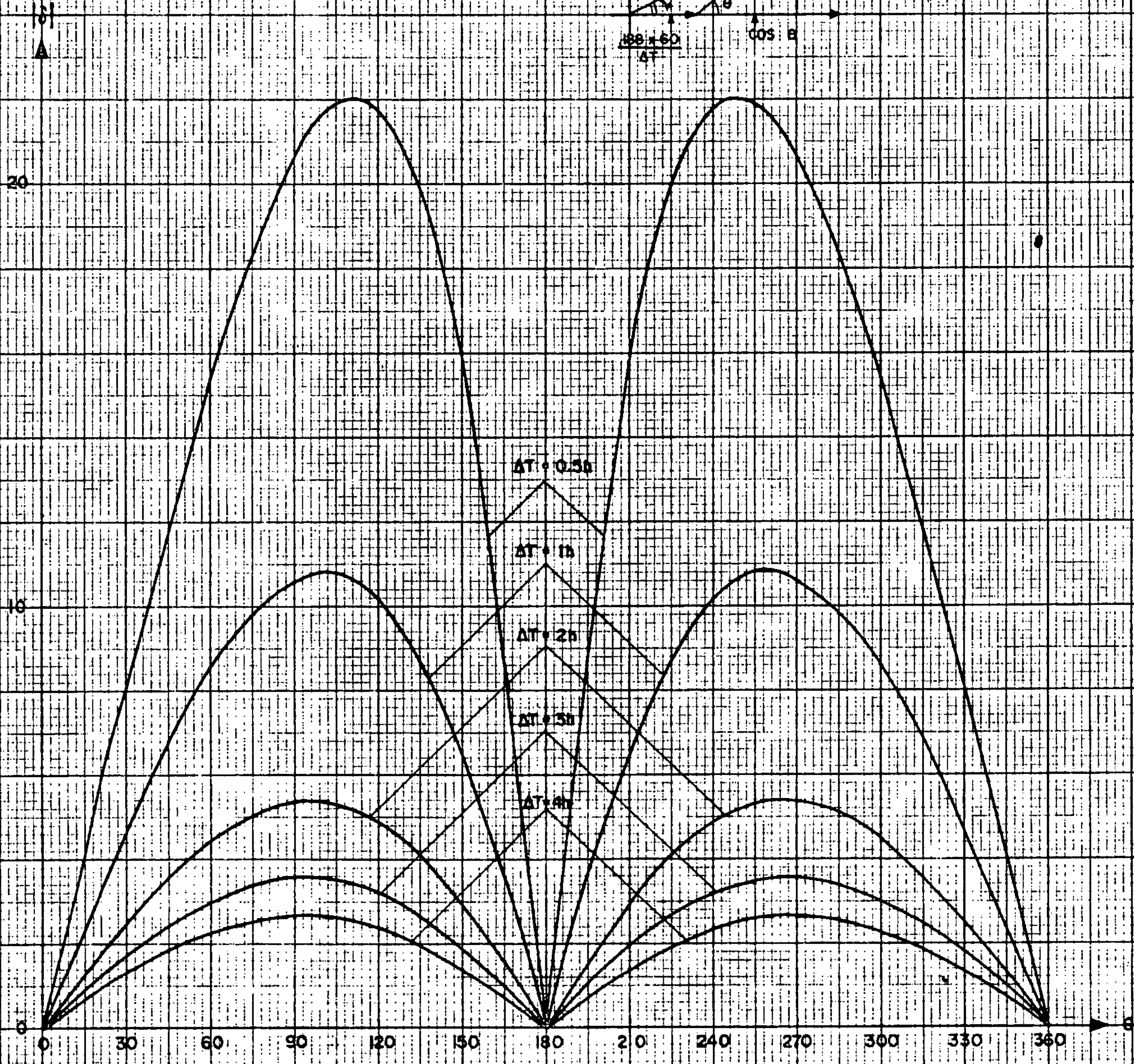
$$tg\,\gamma = \frac{1.\sin\theta}{\frac{.188 \times 60}{\Delta T} + 1.\cos\theta}$$

ΔT BEING TIME BETWEEN SATELLITES

THE CURVES ARE DRAWN FOR :-

ΔT = 0.5 hour, 1h., 2h., 3h., 4h.





EFFECT OF AN ERROR IN THE SATELLITE FIX LATITUDE ON THE HEADING OF A CURRENT VECTOR

GIVEN A 1 KNOT CURRENT VECTOR, HEADING θ, CALCULATED BETWEEN SATELLITE FIXES S_1 AND S_2 SUPPOSED PERFECT. (θ MEASURED FROM THE LATITUDE AXIS). THEN, IF AN ERROR INTRODUCED ON THE LATITUDES OF BOTH S_1 AND S_2, WHAT WILL BE THE EFFECT ON θ.

LET 75 m BE THE LATITUDE ERROR FOR EACH SATELLITE ; 150 m IS THE MAXIMUM ERROR = .081 MILE AND :-

$\frac{.081 \times 60}{\Delta T}$ KNOTS, WHEN SATELLITES ARE ΔT MINUTES APART, IS THE AMPLITUDE OF THE ERROR VECTOR INTRODUCED.

LET γ BE THE NEW HEADING OF THE CURRENT VECTOR AFTER VECTOR ERROR HAS BEEN INTRODUCED.

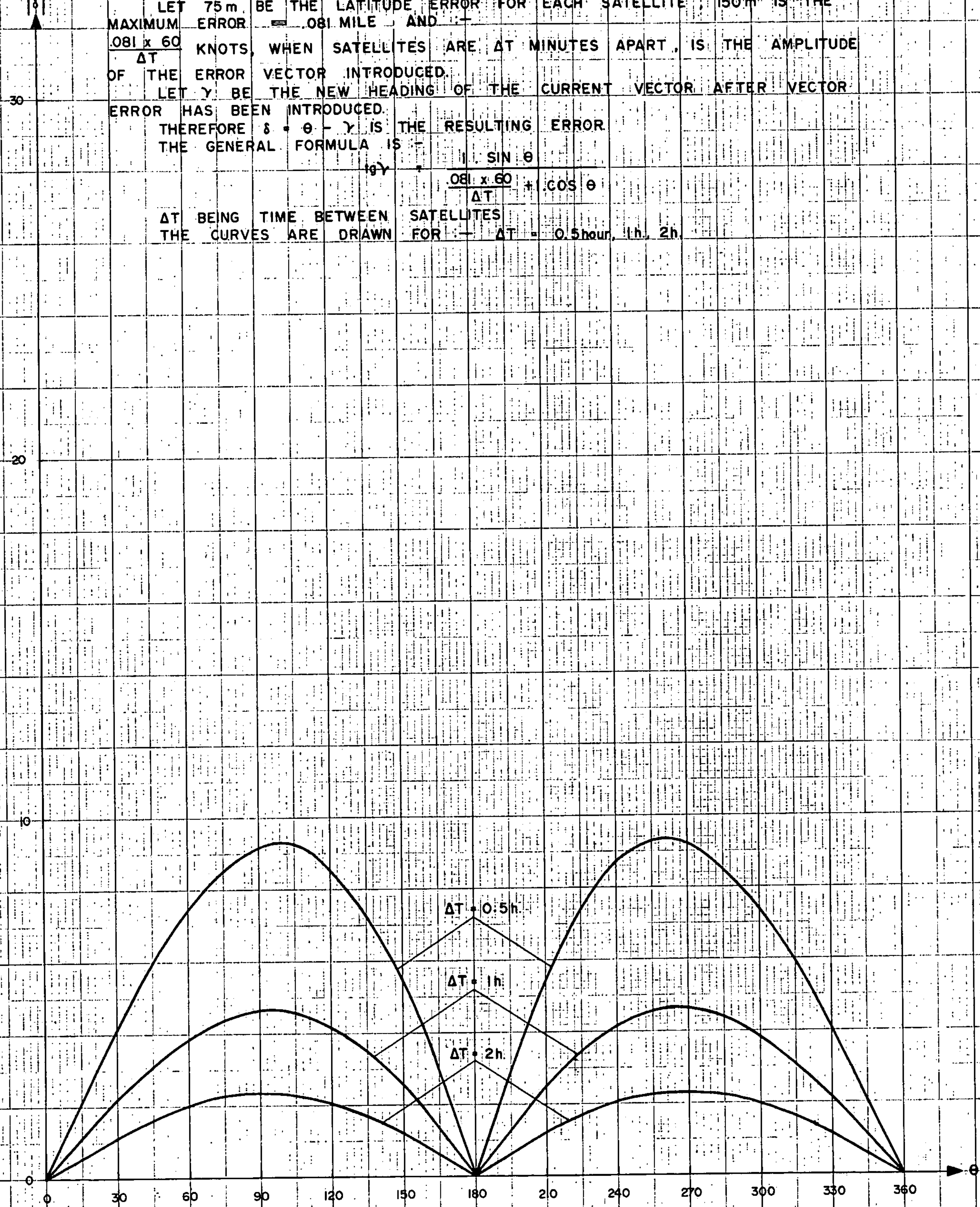
THEREFORE $\delta = \theta - \gamma$ IS THE RESULTING ERROR

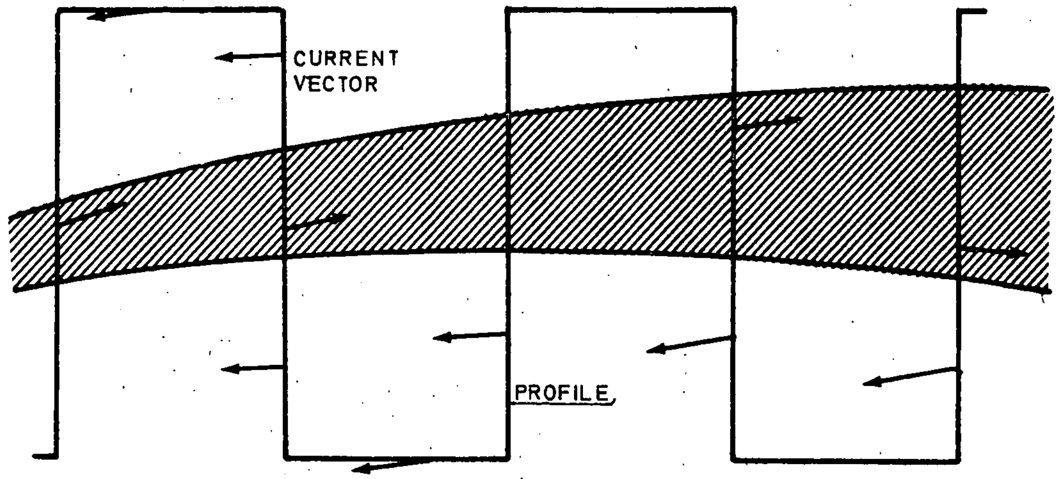
THE GENERAL FORMULA IS :-

$$tg\,\gamma = \frac{1 \cdot \sin\theta}{\frac{.081 \times 60}{\Delta T} + 1 \cdot \cos\theta}$$

ΔT BEING TIME BETWEEN SATELLITES

THE CURVES ARE DRAWN FOR :- ΔT = 0.5 hour, 1h, 2h.

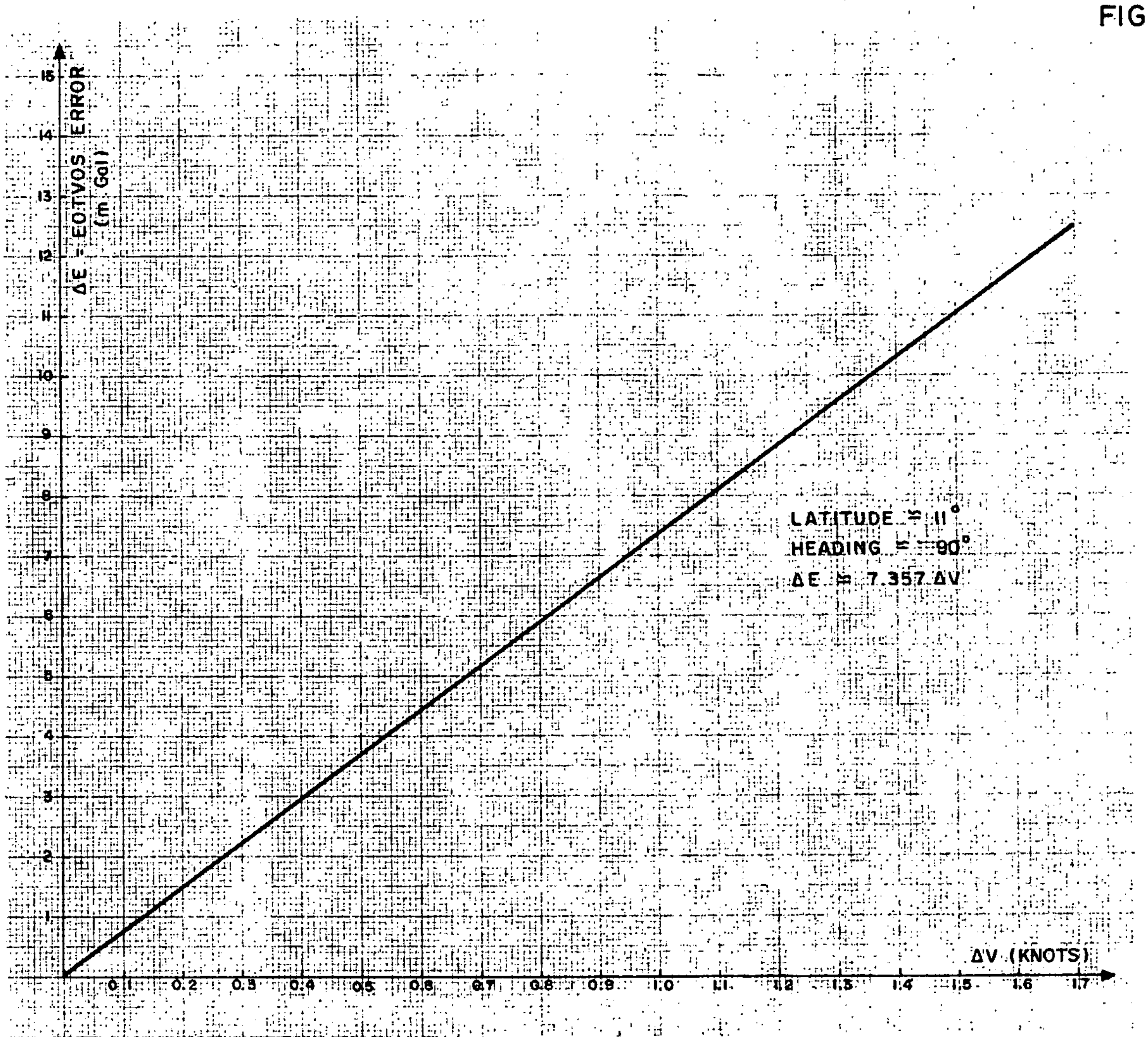




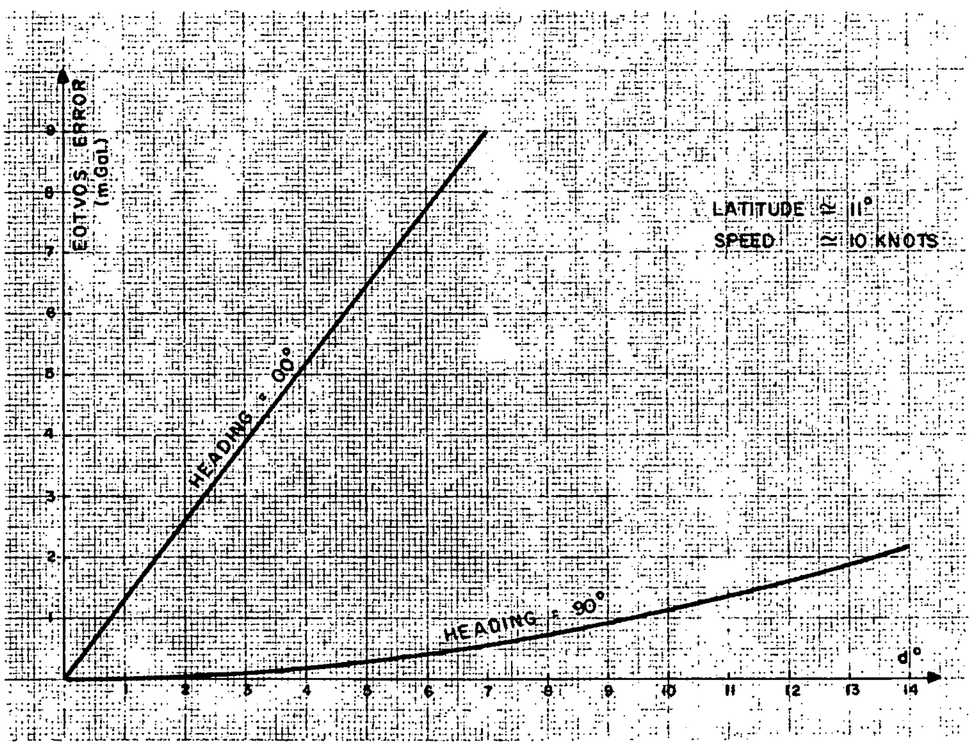
Assuming that the parameters introduced in the computation of the fix (especially the speed of the ship) were perfect, the necessary conditions to define a satellite fix as suspect are either it gives a current which is uncorrelated locally and spatially in heading and speed or it is correlated in heading but not in speed.

The presence of double correlations (heading and speed) is the basis of the current vectors method of assessment. But experience has shown that often such correlations were difficult to locate hence causing indeterminents which this method was unable to erradicate. Areas containing these indeterminents, that is where the pattern of the current vectors are not consistant, correspond mainly to turns, lines near islands and small time intervals between satellite fixes. There also exists the possibility that, for some areas, the effect of the currents was not totally removed when computing the average calibration factor (k) for one system, thus causing erratic headings for some of the error vectors (See Fig. A). This problem may also arise when the quantity (ε) described above becomes non negligable (See Fig. B and C). Thus, to complement this method of assessment

FIG. 46



EOTVOS ERROR FOR VARIATIONS OF EAST VELOCITY ON AN EAST HEADING



EOTVOS ERROR FOR OSCILLATIONS OF THE HEADING ON TWO SPECIFIED COURSES it was necessary to find a more sensitive technique.

2. Velocity vectors assessment method (Printout No. 4. Fig. 44)

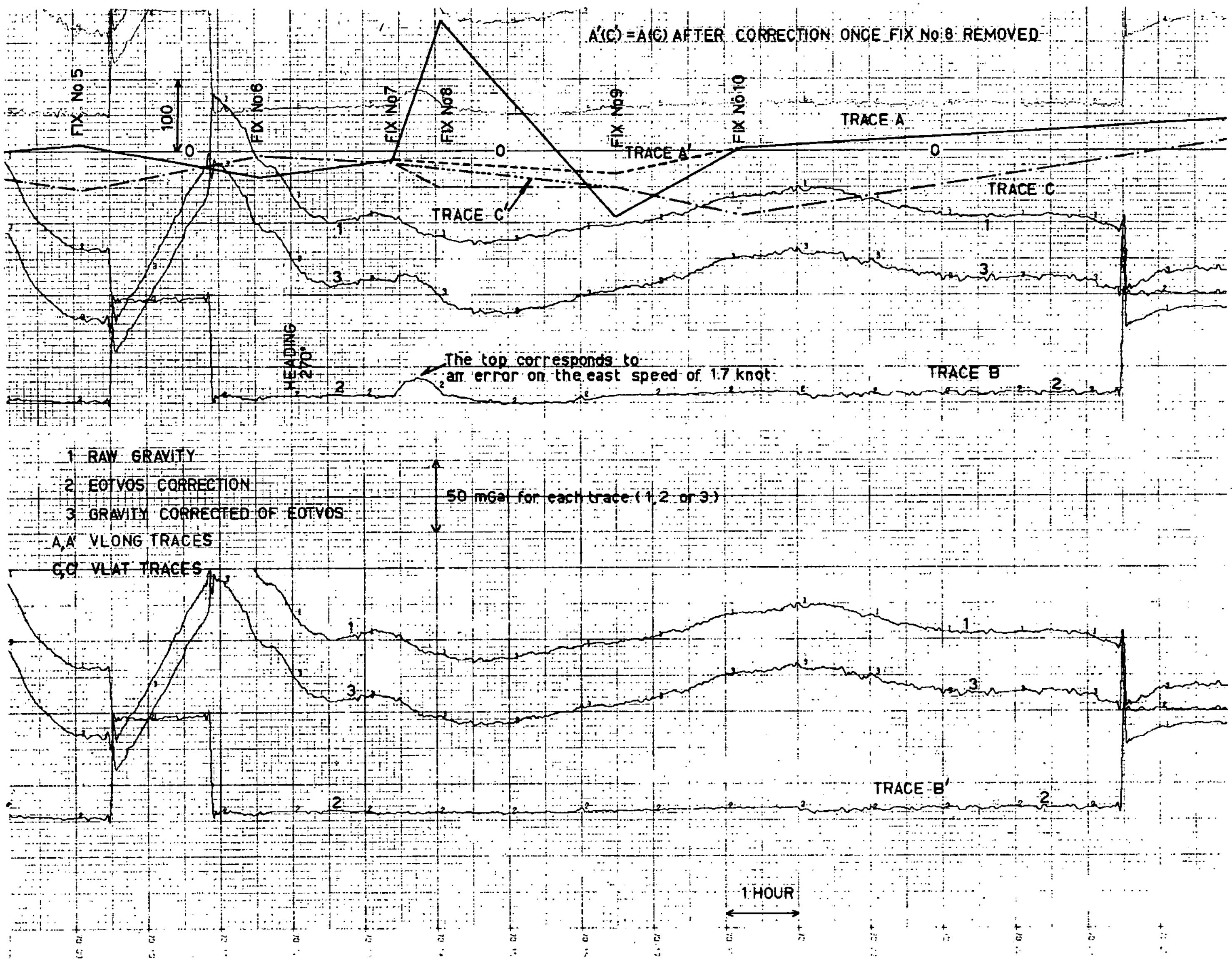
This assessment is realised on the two components of the current vector (Latitude and Longitude) expressed in terms of East and North velocities.
Between Sat (n) at time T(n) and Sat (n+1) at time T (n+1), for each navigation system, two error components ELAT and ELONG are defined, then the following expressions are calculated: (ELAT → ela'i ; ELONG → elo'i - See page 35)

$$(1) \quad VLAT = \frac{ELAT}{T(n+1)-T(n)} \times 10^4$$

$$(2) \quad VLONG = \frac{ELONG}{T(n+1) - T(n)} \times 10^4$$

and are plotted at time T(n+1) (see Fig. 45).
Since $\frac{d}{dt}$ LONG is identical to K. EOTVOS, then the smoother the curve $\frac{d}{dt}$ LONG, the smoother the EOTVOS trace will be. (Fig. 46)
One condition for the smoothness of the curve $\frac{d}{dt}$ LONG is the quietness of the trace joining the "velocity vector errors" VLONG at the times of successive satellite fixes.
Although the satellite system is less sensitive to errors in latitude an assessment is carried out on the VLAT trace in parallel with that on the VLONG trace.

Example of assessment: (Fig. 47 and 48)
In this example, the method is described for the case of VLAT



EXAMPLE OF CORRECTION BY THE VELOCITY VECTORS ASSESSMENT METHOD

FIG. 47

LATITUDE								LONGITUDE							
BEFORE CORRECTIONS				AFTER CORRECTIONS				BEFORE CORRECTIONS				AFTER CORRECTIONS			
FIX No.	No. of minutes between fixes	ELAT	VLAT	FIX No.	No. of minutes between fixes	ELAT	VLAT	FIX No.	No. of minutes between fixes	ELONG	VLONG	FIX No.	No. of minutes between fixes	ELONG	VLONG
5	404	-2.22	-55	5	404	-2.22	-55	5	404	.35	+9	5	404	.35	+9
6	148	-.10	-7	6	148	-.10	-7	6	148	-.55	-37	6	148	-.55	-37
7	110	-.18	-16	7	110	-.18	-16	7	110	-.12	-11	7	110	-.12	-11
8	40	-.20	-50					8	40	.72	+180				
9	146	-.73	-50	9	186	-.93	-50	9	146	-1.34	-92	9	186	-.62	-33
10	104	-.92	-88	10	104	-.92	-88	10	104	.04	+4	10	104	.04	+4
11	410	.68	+17	11	410	.68	+17	11	410	1.84	+45	11	410	1.84	+45

Notes.

* On the line corresponding to Sat n, the figures given are calculated between Sat n-1 and Sat n.

* If satellite fix 4 is removed, then $ELONG_{(3-5)} = ELONG_{(3-4)} + ELONG_{(4-5)}$

$$VLONG_{(3-5)} = \frac{ELONG\ (3-4) + ELONG(4-5)}{(T_5 - T_3)\ \text{minutes}} \times 10^4$$

(The same for ELAT)

Fig. 48 Example of correction by the velocity vectors assessment method (Data corresponding to Fig. 47)

iv. CALNAV assessment.

Once the poor satellites found by the CALNA assessment have been eliminated, CALNAV is run.

A plot is made from the CALNAV output which contains:

- Eotvos correction corresponding to Sonar Doppler.
- Eotvos correction corresponding to Chernikeeff Log.
- Raw gravity.
- gravity corrected from Sonar Doppler EOTVOS
- gravity corrected from Chernikeeff EOTVOS

This plot is assessed in order to select the navigation system(s) which will be used in the next programme.

When a change of system is decided, this change will be made progressive in order to avoid discontinuities. To enable this gradual change of system to be achieved, the time interval for the change is "evaluated" from the "Max Dif" (See Printout No. 2) between the two systems.

III - 3. EOTMAG - GRADED I.

Purpose: the purpose of these two programmes is:

- the controlled selection of one navigation system.
- the correction of the gravity data from Eotuos effect either by algebraic summation or cross - correlation
- the controlled selection of magnetic shore diurnal data

- the correction of the magnetic data from diurnal effect (optional).

III - 3 - 1. Processing

Although intrinsically one programme, and during production processed as such, the routines required were designed, for convenience, as two programmes and therefore will be described here under their separate names.

Prior to the running of these programmes, two assessments are carried out and the results used to control the processing by parameter cards:

1. the output from SHOMAG (see Chapter IV), a tape containing the magnetic shore diurnals, is assessed and where any part of this output is to be ignored (particularly gaps interpolated by Spline method), parameter cards are prepared for EOTMAG.

2. the final assessment from CALNAV determines which navigation system is to be used and the period of time (which may be zero) during which a gradual change from one system to the next is to be implemented. A special case exists when no navigation system is valid, then, all data other than time is set to 1.0 E10. The parameters determined for this selection are supplied to EOTMAG and a further part of the assessment enables the parameters for GRADED I to be selected (Choice of the gravity trace: raw trace or cross correlated trace, and choice of the cross correlation parameters.)

i. EOTMAG processing.

* Controlled selection of navigation system: if a gradual change of system has been decided, then, the resultant navigation system is calculated as a linear proportion of the two systems, dependent on time, from 100% of the old system and zero percent of the new to zero percent of the old system and 100% of the new. Hence, at any point "n%" along the defined time interval, the resultant is (100-n)% old system plus n% of the new.

* The Eotvos correction is computed.

* Controlled selection of magnetic shore-diurnal data.

* Ship magnetic data are corrected from diurnal effect (opt.)

ii. GRADED I processing.

* Controlled selection of the gravity data as a result of previous assessment. The choices are either the raw gravity or the gravity after the cross correlation performed in GRANAV.

* The chosen gravity is corrected from Eotvos effect by algebraic summation (opt. processing)

* The chosen gravity is corrected from Eotvos effect by cross correlation, as described hereunder:

1. Separation of high frequency components:

A moving median is first applied on the two traces Gravity (G) and Eotvos (E) to extract the low frequency components G_{LF} and E_{LF}.

These low frequency components are smoothed using a moving average; the result, G_{LF} smooth and E_{LF} smooth, is substracted from original data. (As a result of the 2 processes Median plus average, G_{HF} and E_{HF} are normalised (or centralised).

2. Cross Correlation. (See Appendix 4).

Cross correlation is performed with the normalised high frequency components G_{HF} and E_{HF}, provided the length of the data exceeds a number of minutes, controlled by a parameter card, currently set to 42; (this number, which depends upon the three parameters: length of the frequency separation window, length of the correlation window and length of the authorised maximum time shift, is in fact a safety coefficient). If the length of the data is smaller than 42 minutes, then, no cross correlation is performed and the simple algebraic sum of gravity and Eotvos correction is done; this occurs, for example, at the start and end of a gap.

Particular problem: during a turn, the cross correlation process does not perform, most of the time, acceptably. Hence, it was necessary to design a special routine now described: when, and only when cross correlation is performed a check is made to see if the vessel was changing east velocity (turn or change of speed when sailing east of west). This is done by examining the normalised high frequency components of gravity and Eotvos correction. At each 1-minute value (T), the normalised high frequency component (NHFC) of the Eotvos is examined within a window (specified by parameter card) to find equal values of opposite signs that exceed a threshold value(specified by parameter card) and are equidistant in time from the 1-minute value(T)

FIG. 49

GRADED 1

SPECIAL PROCESSING

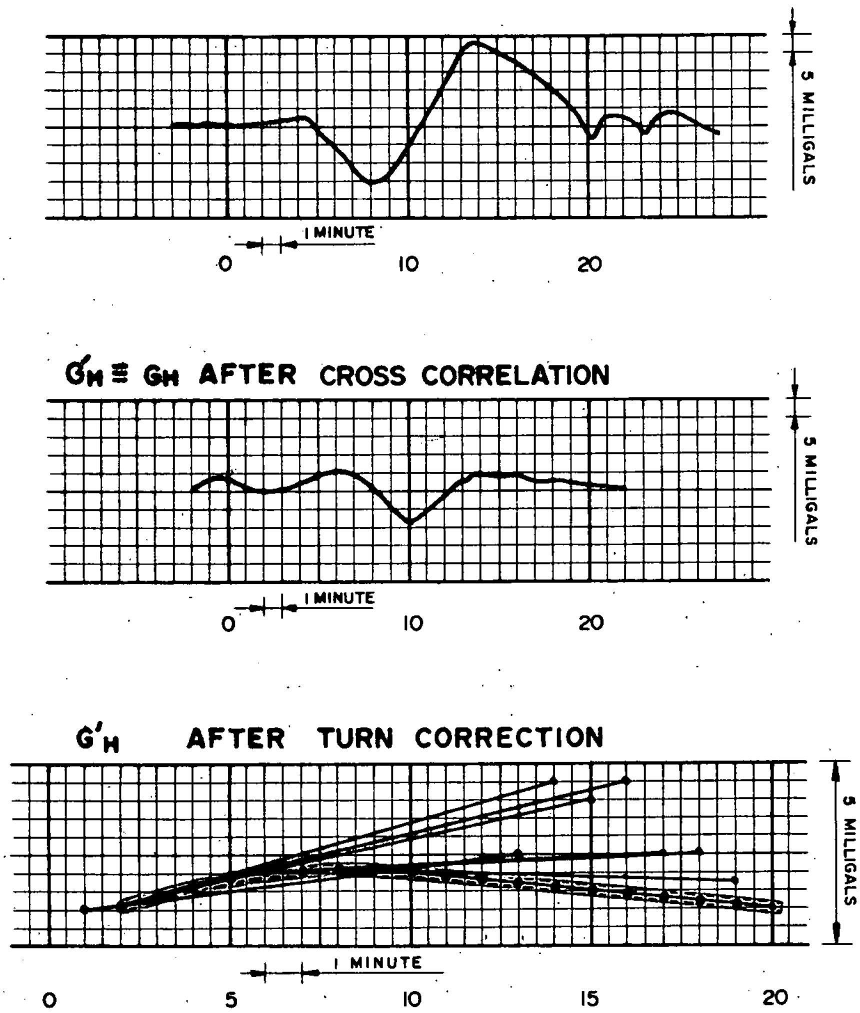
FOR GRAVITY+EÖTVOS CORRECTION (DETAIL)

EXAMPLE ON IMAGINARY DATA FOR CLARITY

EÖTVOS HIGH FREQUENCY ≡ E_H

G'_H ≡ G_H AFTER CROSS CORRELATION

G'_H AFTER TURN CORRECTION



• values before

o values after

G_H : High frequency component of the gravity

currently under consideration. If found, the two values of the NHFC of gravity at the same time positions are examined to check whether they also satisfy the same conditions. If all conditions are satisfied, a change of east speed is assumed and the following processing is performed:
The cross-correlated value at the time T is replaced by the mean of the values at the time positions just outside a time interval, specified on a parameter card, before and after time T, then the remaining data within the time interval before and after the time T are replaced by linear interpolation and extrapolation from the new value at time T and the value at the time + 1 minute + Time interval.

Regardless of whether or not a change of east speed was found, similar processing takes place at the next 1-minute after time T using the new cross-correlated values. Hence for a change of east speed, the cross correlated values are replaced by a smooth curve (Fig. 49 and 50) which may be considered as the envelope of this set of straight lines.

Finally, to the corrected high frequency of Gravity are added back the low frequencies G_L and E_L.
(Note: the parameters currently used for cross correlation and removing of spurious effects during turns are given in Appendix 4).

* The data output from GRADED I for input to GRADED II are examined in exact one-hour blocks and if, for the whole hour, there is simultaneously no gravity, magnetism and depth

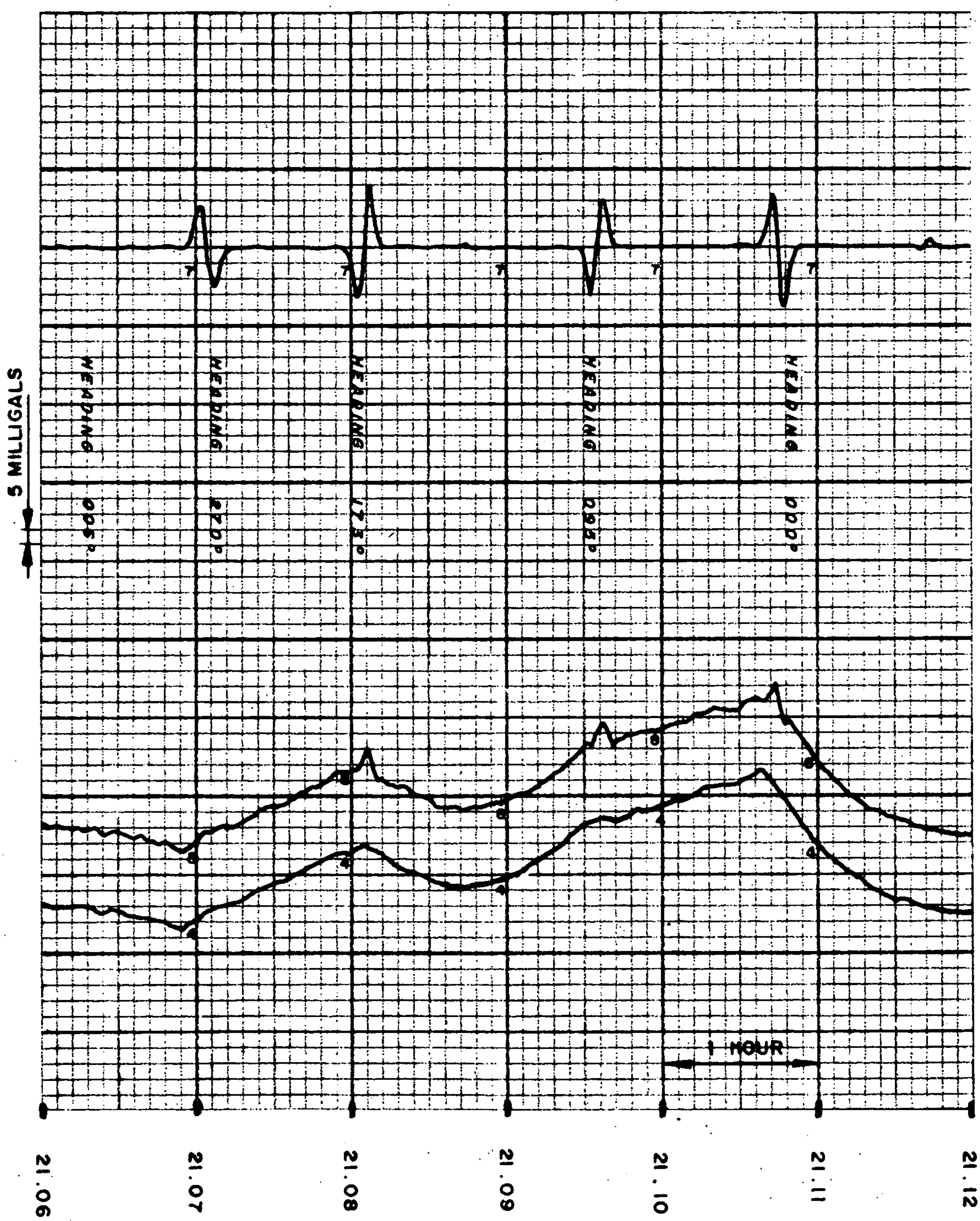
FIG. 50

GRADED PROCESSING FOR EÖTVOS CORRECTION

CHANNEL 7 : EÖTVOS CORRECTION HIGH FREQUENCY

CHANNEL 4 : GRAVITY CORRECTED OF EÖTVOS BY PROCESSING

CHANNEL 8 : GRAVITY CORRECTED OF EÖTVOS BY ALGEBRAIC SUMMATION



SURVEY 05

```
PROGRAM EOTMAG - REPRT.
 OUTPUT CHANNEL NOS.
 INPUT CHANNELS 8 - 16 :     4    5    6    7    8    9   10   11   12
LATITUDE.LONGITUDE :     2    3
 EOTUOS :    14
 SHORE MAG. SHIP MAG :    13   10
 GRAVITY :     6
BETWEEN    0.0000 AND    0.0000 CHANGE TO SYSTEM NO.  1
BETWEEN   45.2306 AND   46.0006 CHANGE TO SYSTEM NO.  2
                                        BEGIN 100 PERCENT NAVIGATION SYSTEM 1 AT   37.1600
 GAP FORCED IN MAG IN INTERVAL    35.0130   35.0400
 GAP FORCED IN MAG IN INTERVAL    38.0110   38.0620
 GAP FORCED IN MAG IN INTERVAL    38.0800   38.1100
 GAP FORCED IN MAG IN INTERVAL    38.1200   38.1300
 GAP FORCED IN MAG IN INTERVAL    41.2330   42.1020
 GAP FORCED IN MAG IN INTERVAL    50.2350   51.0010
BETWEEN   46.0742 AND   46.0842 CHANGE TO SYSTEM NO.  1
                                        BEGIN 100 PERCENT NAVIGATION SYSTEM 2 AT   46.0007
BETWEEN   99.2359 AND   99.2359 CHANGE TO SYSTEM NO. -0
                                        BEGIN 100 PERCENT NAVIGATION SYSTEM 1 AT   46.0843
 END OF JOB - NO INPUT BLOCK =    388 NO OUTPUT BLOCKS=   388
```

GRADUAL CHANGE OF NAVIGATION SYSTEM

DELETION OF SHORE MAGNETIC DATA _ see report

EOTMAG PRINT-OUT

SURVEY 05

FIG. 51

the one-hour block is not output. For the blocks output, the latitude, longitude and depth are examined and if of an excessively large value they are replaced by 1.0 E10.

* Correction of data can be made, using EDIT format data cards. Only replacing of values are done without any interpolation between input values.

III - 3 - 2. Outputs from EOTMAG and GRADED I.

i. Printouts

- from EOTMAG (fig. 51): times of use of each navigation system and duration of overlap; times of deletion of channel 2 to 16 (system No. 0) and shore diurnal magnetic data.
- from GRADED 1 (fig. 52): parameters of gravity processing.

ii. Magnetic tapes

- INTER : Output from EOTMAG.
- Tape 20 : Output from GRADED I for further processing
- Tape 25 : Output from GRADED I for checking of gravity processing. This tape may be plotted.

Format of these tapes is given in appendix 1.

III - 3 - 3. EOTMAG + GRADED I assessment:

Tape 25 is plotted in order to check if Eotvos correction has been correctly applied especially at turns and change of east velocity. If the corrections are not satisfactory, EDIT correction cards are made and gravity is corrected through BMR's EDIT programme.

GRADED PRINT-OUT

SURVEY 05

GRADED JOB REPORT.

RUN PARAMETERS-

SKIP 0 AND PROCESS 1000 BLOCKS.

SHIFTS(MINS,+VE EARLIER)- EOTVOS- 0 GRAVITY CORRECTIONS 2

INPUT CHANNEL NOS - GRAV	MAG	SH.M	DEP	EOT
6	10	13	5	14

PLOT O/P OPTION 1

TRITON PARAMETERS - HALF WINDOWS - FILT CORR SHFT - GAMMAMAX 5 5 3 3.00

TURN FIX PARAMETERS - SEEK H/W, INTERP H/W, THRESHOLD ARERE - 5 5 5.0

GRAVITY AND EOTVOS PROCESSING

GRAVITY ZERO 999999.900 DUMMY VALUE AS NO CORRECTION CARD ARE USED

CORRECTIONS	0.0	1028.2	2056.4	3084.5	4112.6	5140.7	6169.1	7197.8	8226.7	9255.5	10284.1	11311.7	12337.8
INT. FACTS.	1.0282	1.0282	1.0281	1.0281	1.0281	1.0284	1.0287	1.0289	1.0288	1.0286	1.0276	1.0261	-0.0000

END OF GRAVITY PROCESSING PHASE

INPUT,OUTPUT BLOCK COUNTS ARE RESPEC. 388 388

START TIMES OF 1ST,LAST OUTPUTBLOCKSARE RESP. 37.1600 53.1900

FIG. 52

III - 4. GRADED II, or GRADEUX

The purpose of this programme is to put the data in standard B.M.R format through B.M.R tape 67 programme.

The inputs of GRADED II are all the tapes of one survey. The output will be one tape for the whole survey.

III - 4 - 1 Processing

* Each data record is put in a continuous segment of data usually covering one day recording. By this, it is meant that there is no time gap(s) in the record. Short gaps are covered by setting the data channels values as 1.0 E10. But should a time gap exceed one hour, a new record is created.

* A new segment is started for each survey day number. So a segment never exceeds one day recording. But there may be several segments to a day if there is major breaks in surveying.

* A header summarising the status of the information within the segment is put before each data block. Output file is labelled with the name of the area surveyed and number of the survey as follows:

GULF OF PAPUA AND BISMARK SEA, SURVEY 05
NORTHERN CORAL SEA, SURVEY 10
SOUTHERN TASMANIA, SURVEY 11
TASMAN SEA, SURVEY 12
SOUTHERN CORAL SEA, SURVEY 13
CENTRAL CORAL SEA, SURVEY 14

```
***** LIST OF SEGMENTS ON TAPE LABELLED *GULF OF PAPUA AND BISMARK SEA, SURVEY 05

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 58                    *
      420  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 59                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 60                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 61                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 62                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 63                    *
      120  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 64                    *
      840  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 65                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 66                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 67                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 68                    *
     1440  STATIONS IN SEGMENT

*GULF OF PAPUA AND BISMARK SEA, SURVEY 05 - DAY 69                    *
     1440  STATIONS IN SEGMENT
```

GRADED II PRINT-OUT

SURVEY 05

FIG. 53

EASTERN COAST, SURVEY 15

SOUTHERN COAST, SURVEY 16

WESTERN COAST, SURVEY 17

INDIAN OCEAN, SURVEY 18

SOUTH EASTERN COAST, SURVEY 19.

III - 4 - 2. GRADED II outputs.

i. Printout (Fig. 53) gives:

- For one whole survey, standard header of the surveyed area.

- List of segments of the tape with number of stations in segments (one station is an one-minute sample).

ii. Magnetic tape. (Appendix 1)

One minute data tape (for whole survey) for further processing such as contouring.

This is the final tape of Phase 2.

IV. OTHER PROCESSINGS.

Out of the main flow of processing, several other programmes were designed:

- to process satellite data
- to digitize analogue data.
- to plot and print magnetic tapes.

IV. I. SATELLITE DATA PROCESSING.

Purpose: to recalculate on the CSIRO 3600 all the satellite fixes recorded on board the ship.

First, satellite data magnetic tape received from the ship is converted to CDC 3600 format. Then, satellite fixes are recalculated. (Note: for both surveys, the computations used the 2 minute Dopplers.)

IV. I.I. Processing.

The programme works in three phases:

* First phase: a predicted value of the offset frequency is introduced in the fix computation so that the only unknown quantities are longitude and latitude. The prediction of the offset frequency is derived from the previous observations on the same satellite in two ways:

- by means of a hand smoothed curve of the variation of the offset frequency kept up to date for each satellite. (Method used for Surveys 05 and 10 to 16) (Fig. 54)
- by means of a computer smoothed curve of the variation of the offset frequency (Fig. 55 to 57), using the programme SPOOF (See Appendix 6).

If n Dopplers were observed, the fix is calculated using the n Dopplers and is accepted or rejected depending on the RMS value of the residuals (differences between observed Dopplers and the theoretical ones corresponding to the calculated position). If the RMS is lesser than 10, the fix

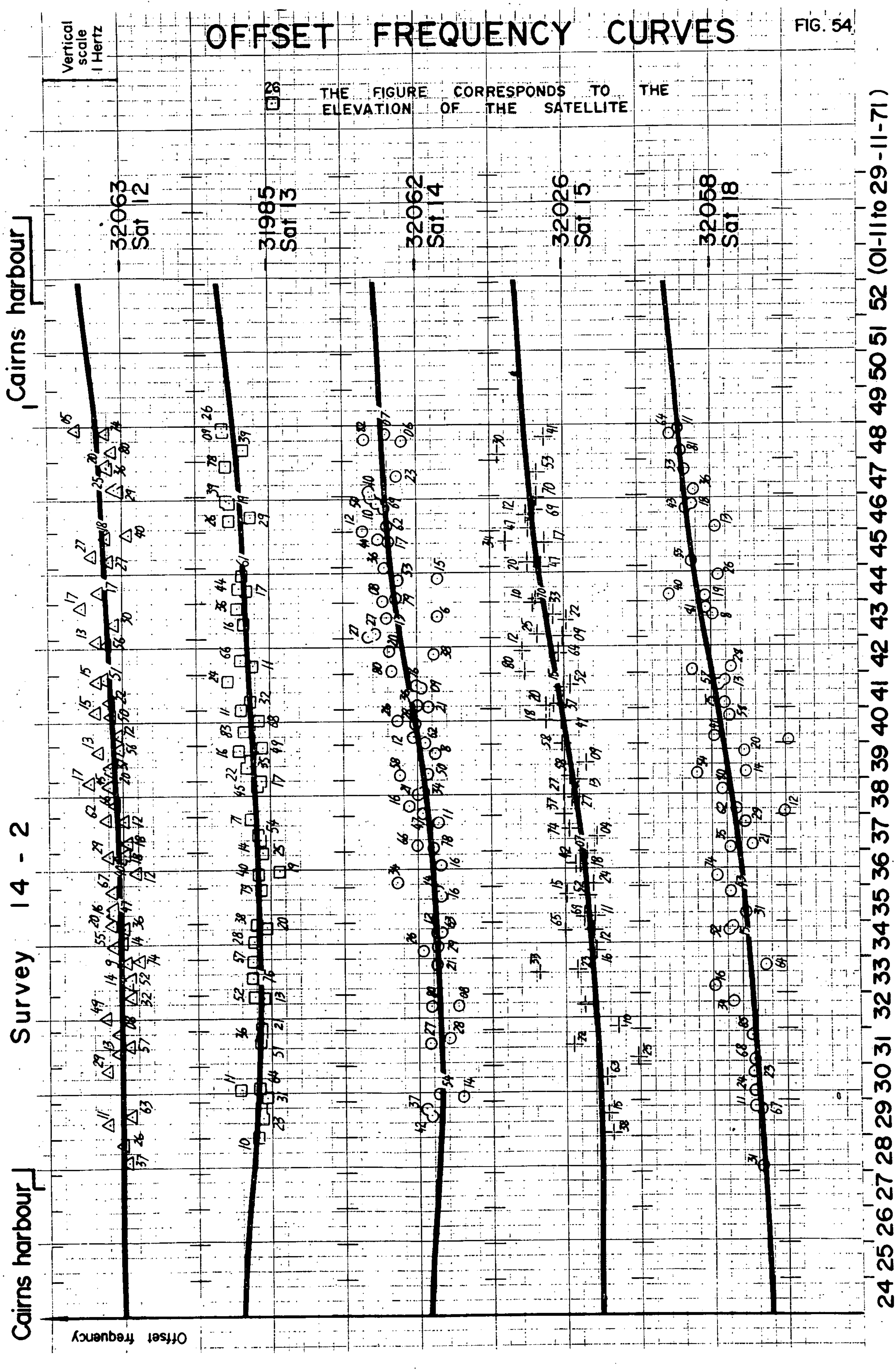

OFFSET FREQUENCY CURVES
Vertical scale 1 Hertz
26 □ THE FIGURE CORRESPONDS TO THE ELEVATION OF THE SATELLITE
Cairns harbour
Survey 14 - 2
Cairns harbour
32063 Sat 12
31985 Sat 13
32062 Sat 14
32026 Sat 5
32058 Sat 18
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 (01-11 to 29-11-71)
Offset frequency

FIG. 54

PLOT OF RAW AND SMOOTHED OFFSET FREQUENCIES OF

SATELLITE FIXES FOR

SURVEY 18
CRUISE 1

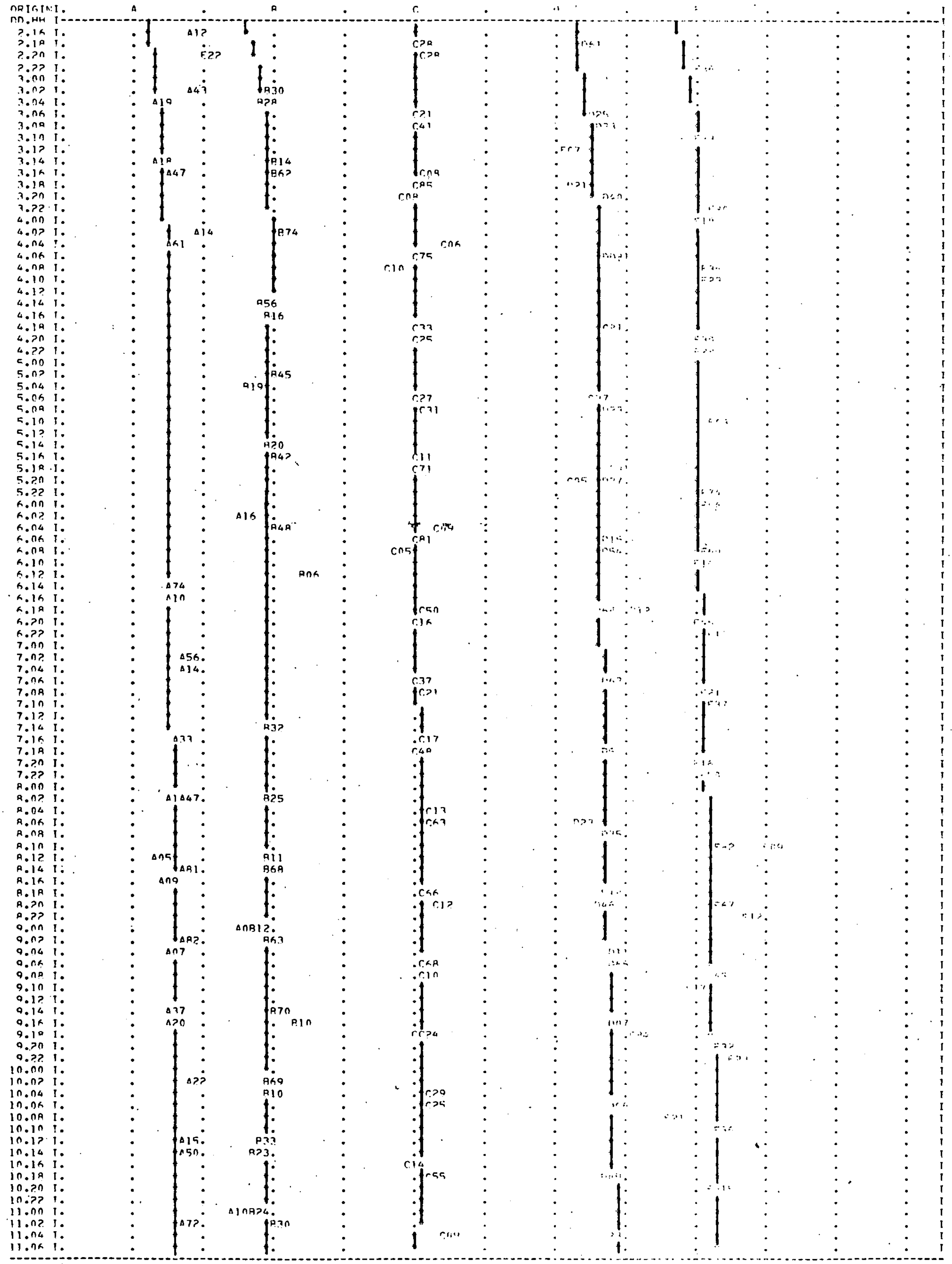
SPOOF PRINT-OUT

FIG. 55

SCALE IS .10 HERTZ TO ONE PRINT POSITION.

SATELLITE NO 12 HAS VALUE 32073.00 AT ORDINATE 10 AND PLOT CODE -A-.
SATELLITE NO 13 HAS VALUE 31991.00 AT ORDINATE 30 AND PLOT CODE -B-.
SATELLITE NO 14 HAS VALUE 32072.00 AT ORDINATE 50 AND PLOT CODE -C-.
SATELLITE NO 15 HAS VALUE 32036.00 AT ORDINATE 70 AND PLOT CODE -D-.
SATELLITE NO 18 HAS VALUE 32070.00 AT ORDINATE 90 AND PLOT CODE -E-.

FIGURE AFTER LETTER CODE IS ELEVATION OF SATELLITE



SPOOF PRINT - OUT

FIG. 56

SURVEY 18 - CRUISE 1

SATELLITE NO. 12 - NO OF FIXES = 29

DD HHMM	RAW freq.	SMOOTHED f.	WEIGHT
2.1714	32073.77	32073.22	.22
3.0314	32073.76	32073.34	.33
3.0500	32073.30	32073.35	1.00
3.1432	32073.31	32073.41	1.00
3.1618	32073.54	32073.42	1.00
4.0220	32073.92	32073.45	.11
4.0404	32073.53	32073.45	1.00
6.0220	32074.52	32073.46	0.00
6.1520	32073.46	32073.49	1.00
6.1708	32073.53	32073.49	1.00
7.0304	32073.71	32073.52	1.00
7.0452	32073.74	32073.52	.44
7.1612	32073.58	32073.55	1.00
8.0210	32073.47	32073.58	1.00
8.0354	32073.70	32073.58	1.00
8.1334	32073.29	32073.60	.22
8.1518	32073.75	32073.61	.44
8.1708	32073.38	32073.61	.44
9.0118	32074.48	32073.62	0.00
9.0258	32073.74	32073.63	1.00
9.0450	32073.46	32073.63	1.00
9.1422	32073.54	32073.64	1.00
9.1610	32073.47	32073.64	1.00
10.0204	32073.78	32073.64	1.00
10.0350	32073.76	32073.64	1.00
10.1330	32073.69	32073.65	1.00
10.1514	32073.68	32073.65	1.00
11.0112	32074.39	32073.65	0.00
11.0254	32073.68	32073.65	1.00

SATELLITE NO. 13 - NO OF FIXES = 27

3.0254	31990.77	31990.72	1.00
3.0440	31990.73	31990.74	1.00
3.1414	31990.93	31990.82	1.00
3.1600	31991.01	31990.83	.67
4.0350	31991.06	31990.86	.33
4.1512	31990.67	31990.84	1.00
4.1700	31990.80	31990.84	1.00
5.0300	31990.86	31990.81	1.00
5.0448	31990.51	31990.81	.22
5.1426	31990.79	31990.78	1.00
5.1612	31990.91	31990.78	1.00
6.0404	31990.98	31990.76	1.00
6.1340	31991.38	31990.76	0.00
7.1434	31990.79	31990.79	1.00
8.0220	31990.79	31990.80	1.00
8.1348	31990.82	31990.82	1.00
8.1532	31990.80	31990.82	1.00
9.0134	31990.60	31990.82	.33
9.0318	31990.78	31990.82	1.00
9.1444	31990.92	31990.82	1.00
9.1638	31991.28	31990.82	.22
10.0228	31990.78	31990.82	1.00
10.0418	31990.84	31990.82	1.00
10.1356	31990.74	31990.81	1.00
10.1544	31990.56	31990.81	.22
11.0140	31990.63	31990.80	.33
11.0328	31990.99	31990.80	1.00

SATELLITE NO. 14 - NO OF FIXES = 40

2.1838	32072.00	32071.89	1.00
2.2026	32072.10	32071.90	.67
3.0628	32071.99	32071.92	1.00
3.0812	32071.99	32071.92	1.00
3.1744	32072.07	32071.92	.44
3.1932	32071.94	32071.92	1.00
3.2120	32071.68	32071.92	1.00
4.0540	32072.42	32071.92	0.00
4.0720	32072.01	32071.91	1.00
4.0910	32071.47	32071.91	0.00
4.1842	32071.97	32071.90	1.00
4.1950	32037.05	32071.90	0.00
4.2030	32071.90	32071.90	1.00
5.0630	32071.96	32071.90	1.00
5.0816	32072.07	32071.90	1.00
5.1754	32071.86	32071.91	1.00
5.1938	32071.98	32071.91	1.00
5.2128	32074.19	32071.92	0.00
6.0540	32072.34	32071.94	.22
6.0722	32071.88	32071.94	1.00
6.0914	32071.64	32071.95	.22
6.1846	32072.07	32071.99	1.00
6.2034	32072.01	32071.99	1.00
7.0634	32072.03	32072.03	1.00
7.0820	32072.05	32072.04	1.00
7.1756	32072.12	32072.05	1.00
7.1942	32072.01	32072.08	1.00
8.0542	32072.21	32072.11	.44
8.0726	32072.17	32072.12	1.00
8.1852	32072.12	32072.13	1.00
8.2040	32072.26	32072.14	.33
9.0634	32072.06	32072.14	1.00
9.0824	32072.10	32072.14	1.00
9.1802	32071.98	32072.13	1.00
9.1948	32072.14	32072.12	1.00
10.0544	32072.19	32072.10	1.00
10.0730	32072.17	32072.10	1.00
10.1710	32071.83	32072.08	.33
10.1900	32072.16	32072.07	1.00
11.0456	32072.44	32072.04	.22

CRUISE 1

SATELLITE NO. 15 - NO OF FIXES = 28

2.1938	32036.41	32036.31	1.00
3.0658	32036.52	32036.45	1.00
3.0844	32036.58	32036.47	1.00
3.1852	32036.20	32036.54	1.00
3.2036	32036.71	32036.55	1.00
4.0612	32036.65	32036.59	1.00
4.0758	32036.82	32036.59	.33
5.0710	32036.50	32036.62	1.00
5.0858	32036.75	32036.62	1.00
5.1902	32036.80	32036.62	.44
5.2046	32036.72	32036.62	1.00
6.0622	32036.68	32036.63	1.00
6.0808	32036.66	32036.63	1.00
6.1812	32037.12	32036.64	0.00
6.1956	32036.59	32036.64	1.00
7.0720	32036.70	32036.66	1.00
7.1908	32036.67	32036.68	1.00
8.0632	32036.32	32036.70	.22
8.0820	32036.71	32036.71	1.00
8.1820	32036.74	32036.73	1.00
8.2006	32036.64	32036.73	1.00
9.0546	32036.84	32036.76	1.00
9.0732	32036.82	32036.76	1.00
9.1734	32036.94	32036.78	1.00
9.1920	32037.08	32036.79	.22
10.0642	32036.76	32036.82	1.00
10.1828	32036.75	32036.85	1.00
11.0556	32036.67	32036.88	1.00

SATELLITE NO. 18 - NO OF FIXES = 33

2.2128	32075.47	32069.74	0.00
2.2310	32069.94	32069.77	1.00
3.1032	32069.97	32069.91	1.00
3.1218	32067.98	32069.93	0.00
3.2222	32070.17	32070.00	.44
4.0010	32070.00	32070.01	1.00
4.0942	32070.09	32070.03	1.00
4.1128	32070.06	32070.03	1.00
4.2132	32069.96	32070.03	1.00
4.2320	32069.93	32070.03	1.00
5.1040	32070.16	32070.02	1.00
5.2230	32070.14	32070.03	1.00
6.0018	32070.10	32070.03	1.00
6.0952	32070.08	32070.04	1.00
6.1140	32069.95	32070.05	1.00
6.2138	32069.99	32070.07	1.00
6.2330	32070.20	32070.07	1.00
7.0904	32070.09	32070.10	1.00
7.1050	32070.19	32070.10	1.00
7.2052	32069.98	32070.13	1.00
7.2236	32070.11	32070.14	1.00
8.1000	32070.27	32070.17	1.00
8.1152	32071.00	32070.18	0.00
8.2150	32070.31	32070.20	1.00
8.2338	32070.69	32070.21	0.00
9.0914	32070.18	32070.23	1.00
9.1100	32069.94	32070.23	.33
9.2058	32070.29	32070.25	1.00
9.2244	32070.51	32070.26	.33
10.0824	32069.52	32070.28	0.00
10.1010	32070.27	32070.28	1.00
10.2010	32070.31	32070.29	1.00
10.2158	32070.23	32070.30	1.00

FIG. 57

SPOOF PRINT-OUT

SURVEY 18 _ CRUISE I

PRINTOUT OF PUNCHED CARD OUTPUT FILE.

SMOOTHED f.	RAW frequency	WEIGHT	Elevation	SAT N°	DD HHMM	Survey N°	Δ smoothed-raw
32073.22	32073.77	7	12.	12	2.1714	18	-.5
32071.89	32072.00	0	28.	14	2.1838	18	-.1
32036.31	32036.41	0	61.	15	2.1938	18	-.1
32071.90	32072.10	3	28.	14	2.2026	18	-.2
32069.74	32075.47	9	22.	18	2.2128	18	-5.7
32069.77	32069.94	0	36.	18	2.2310	18	-.2
31990.72	31990.77	0	30.	13	3.0254	18	-.1
32073.34	32073.76	6	43.	12	3.0314	18	-.4
31990.74	31990.73	0	28.	13	3.0440	18	.0
32073.35	32073.30	0	19.	12	3.0500	18	.1
32071.92	32071.99	0	21.	14	3.0628	18	-.1
32036.45	32036.52	0	25.	15	3.0658	18	-.1
32071.92	32071.99	0	41.	14	3.0812	18	-.1
32036.47	32036.58	0	33.	15	3.0844	18	-.1
32069.91	32069.97	0	83.	18	3.1032	18	-.1
32069.93	32067.98	9	7.	18	3.1218	18	2.0
31990.82	31990.93	0	14.	13	3.1414	18	-.1
32073.41	32073.31	0	18.	12	3.1432	18	.1
31990.83	31991.01	3	62.	13	3.1600	18	-.2
32073.42	32073.54	0	47.	12	3.1618	18	-.1
32071.92	32072.07	5	8.	14	3.1748	18	-.1
32036.54	32036.20	0	21.	15	3.1852	18	.3
32071.92	32071.94	0	85.	14	3.1932	18	-.0
32036.55	32036.71	0	40.	15	3.2036	18	-.2
32071.92	32071.68	0	8.	14	3.2120	18	.2
32070.00	32070.17	5	80.	18	3.2222	18	-.2
32070.01	32070.00	0	10.	18	4.0010	18	.0
32073.45	32073.92	8	14.	12	4.0220	18	-.5
31990.86	31991.06	6	74.	13	4.0350	18	-.2
32073.45	32073.53	0	61.	12	4.0404	18	-.1
32071.92	32072.42	9	6.	14	4.0540	18	-.5
32036.59	32036.65	0	9.	15	4.0612	18	-.1
32071.91	32072.01	0	75.	14	4.0720	18	-.1
32036.59	32036.82	6	81.	15	4.0758	18	-.2
32071.91	32071.47	9	10.	14	4.0910	18	.4
32070.03	32070.09	0	36.	18	4.0942	18	-.1
32070.03	32070.06	0	23.	18	4.1128	18	-.0
31990.84	31990.67	0	56.	13	4.1512	18	.2
31990.84	31990.80	0	16.	13	4.1700	18	.0
32071.90	32071.87	0	33.	14	4.1842	18	.0
32071.90	32037.05	9	81.	14	4.1950	18	34.9
32071.90	32071.90	0	25.	14	4.2030	18	.0
32070.03	32069.96	0	30.	18	4.2132	18	.1
32070.03	32069.93	0	28.	18	4.2320	18	.1
31990.81	31990.86	0	45.	13	5.0300	18	-.0
31990.81	31990.51	7	19.	13	5.0448	18	.3
32071.90	32071.96	0	27.	14	5.0630	18	-.1
32036.62	32036.50	0	37.	15	5.0710	18	.1
32071.90	32072.07	0	31.	14	5.0816	18	-.2
32036.62	32036.75	0	23.	15	5.0858	18	-.1
32070.02	32070.16	0	63.	18	5.1040	18	-.1
31990.78	31990.79	0	20.	13	5.1426	18	-.0
31990.78	31990.91	0	42.	13	5.1612	18	-.1
32071.91	32071.86	0	11.	14	5.1754	18	.0
32036.62	32036.80	5	31.	15	5.1902	18	-.2
32071.91	32071.98	0	71.	14	5.1938	18	-.1
32036.62	32036.72	0	27.	15	5.2046	18	-.1
32071.92	32074.19	9	5.	14	5.2128	18	-2.3
32070.03	32070.14	0	74.	18	5.2230	18	-.1
32070.03	32070.10	0	4.	18	6.0018	18	-.1
32073.46	32074.52	9	16.	12	6.0220	18	-1.1
31990.76	31990.98	0	48.	13	6.0404	18	-.2
32071.94	32072.34	7	9.	14	6.0540	18	-.4
32036.63	32036.68	0	15.	15	6.0622	18	-.1
32071.94	32071.88	0	81.	14	6.0722	18	.1
32036.63	32036.66	0	54.	15	6.0808	18	-.0
32071.95	32071.64	7	5.	14	6.0914	18	.3
32070.04	32070.08	0	60.	18	6.0952	18	-.0
32070.05	32069.95	0	14.	18	6.1140	18	.1
31990.76	31991.38	9	6.	13	6.1340	18	-.6
32073.49	32073.46	0	74.	12	6.1520	18	.0
32073.49	32073.53	0	10.	12	6.1708	18	-.0
32036.64	32037.12	9	12.	15	6.1812	18	-.5
32071.99	32072.07	0	50.	14	6.1846	18	-.1
32036.64	32036.59	0	68.	15	6.1956	18	.1
32071.99	32072.01	0	16.	14	6.2034	18	-.0
32070.07	32069.99	0	46.	18	6.2138	18	.1
32070.07	32070.20	0	18.	18	6.2330	18	-.1
32073.52	32073.71	0	56.	12	7.0304	18	-.2
32073.52	32073.74	5	14.	12	7.0452	18	-.2
32072.03	32072.03	0	37.	14	7.0634	18	.0
32036.66	32036.70	0	63.	15	7.0720	18	-.0
32072.04	32072.05	0	21.	14	7.0820	18	-.0
32070.10	32070.09	0	21.	18	7.0904	18	.0
32070.10	32070.19	0	37.	18	7.1050	18	-.1
31990.79	31990.79	0	32.	13	7.1434	18	-.0
32073.55	32073.58	0	33.	12	7.1612	18	-.0
32072.08	32072.12	0	17.	14	7.1756	18	-.0
32036.68	32036.67	0	50.	15	7.1908	18	.0
32072.08	32072.01	0	48.	14	7.1942	18	.1
32070.13	32069.98	0	16.	18	7.2052	18	.2
32070.14	32070.11	0	50.	18	7.2236	18	.0
32073.58	32073.47	0	17.	12	8.0210	18	.1
31990.80	31990.79	0	25.	13	8.0220	18	.0
32073.58	32073.70	0	47.	12	8.0354	18	-.1
32072.11	32072.21	5	13.	14	8.0542	18	-.1
32036.70	32036.32	7	23.	15	8.0632	18	.4
32072.12	32072.17	0	63.	14	8.0726	18	-.1
32036.71	32036.71	0	35.	15	8.0820	18	-.0
32070.17	32070.27	0	82.	18	8.1000	18	-.1
32070.18	32071.00	9	9.	18	8.1152	18	-.8
32073.60	32073.29	7	5.	12	8.1334	18	.3
31990.82	31990.82	0	11.	13	8.1348	18	-.0
32073.61	32073.75	5	81.	12	8.1518	18	-.1
31990.82	31990.80	0	68.	13	8.1532	18	.0
32073.61	32073.38	5	9.	12	8.1708	18	.2
32036.73	32036.74	0	18.	15	8.1820	18	-.0
32072.13	32072.12	0	66.	14	8.1852	18	.0
32036.73	32036.64	0	46.	15	8.2006	18	.1
32072.14	32072.26	6	12.	14	8.2040	18	-.1
32070.20	32070.31	0	67.	18	8.2150	18	-.1
32070.21	32070.69	9	12.	18	8.2338	18	-.5
32073.62	32074.48	9	5.	12	9.0118	18	-.9
31990.82	31990.60	6	12.	13	9.0134	18	.2
32073.63	32073.74	0	82.	12	9.0258	18	-.1
31990.82	31990.78	0	63.	13	9.0318	18	.0
32073.63	32073.46	0	7.	12	9.0450	18	.2
32036.76	32036.84	0	11.	15	9.0546	18	-.1
32072.14	32072.06	0	68.	14	9.0634	18	.1
32036.76	32036.82	0	66.	15	9.0732	18	-.1
32072.14	32072.10	0	10.	14	9.0824	18	.0
32070.23	32070.19	0	45.	18	9.0914	18	.1
32070.23	32069.84	6	17.	18	9.1100	18	.4
32073.64	32073.54	0	37.	12	9.1422	18	.1

CONTINUATION

31990.82	31990.92	0	70.	13	9.1444	18	-.1
32073.64	32073.47	0	20.	12	9.1610	18	.2
31990.82	31991.28	7	10.	13	9.1638	18	-.5
32036.78	32036.84	0	7.	15	9.1734	18	-.1
32072.13	32071.98	0	31.	14	9.1802	18	.1
32036.79	32037.08	7	84.	15	9.1920	18	-.3
32072.12	32072.14	0	24.	14	9.1948	18	-.0
32070.25	32070.29	0	32.	18	9.2058	18	-.0
32070.26	32070.51	6	23.	18	9.2244	18	-.3
32073.64	32073.78	0	33.	12	10.0204	18	-.1
31990.82	31990.78	0	69.	13	10.0228	18	.0
32073.64	32073.76	0	22.	12	10.0350	18	-.1
31990.82	31990.84	0	10.	13	10.0418	18	-.0
32072.10	32072.19	0	29.	14	10.0544	18	-.1
32036.82	32036.76	0	66.	15	10.0642	18	.1
32072.10	32072.17	0	25.	14	10.0730	18	-.1
32070.28	32069.52	9	21.	18	10.0824	18	.8
32070.28	32070.27	0	36.	18	10.1010	18	.0
32073.65	32073.69	0	15.	12	10.1330	18	-.0
31990.81	31990.74	0	33.	13	10.1356	18	.1
32073.65	32073.68	0	50.	12	10.1514	18	-.0
31990.81	31990.56	7	23.	13	10.1544	18	.3
32072.08	32071.83	6	14.	14	10.1710	18	.2
32036.85	32036.75	0	49.	15	10.1828	18	.1
32072.07	32072.16	0	55.	14	10.1900	18	-.1
32070.29	32070.31	0	15.	18	10.2010	18	-.0
32070.30	32070.23	0	51.	18	10.2158	18	.1
32073.65	32074.39	9	10.	12	11.0112	18	-.7
31990.80	31990.63	6	24.	13	11.0140	18	.2
32073.65	32073.68	0	72.	12	11.0254	18	-.0
31990.80	31990.99	0	30.	13	11.0328	18	-.2
32072.04	32072.44	7	9.	14	11.0456	18	-.4
32036.88	32036.67	0	23.	15	11.0556	18	.2

is accepted; if greater than 10 a new iteration occurs, considering all the possible fixes using (n-1) Dopplers.

If none of these fixes lead to residuals of less than 10 (RMS), a new iteration occurs resulting in all the solutions using (n-2) Dopplers.....

If at a given iteration using (n-p) Dopplers one or several configurations lead to residuals of less than 10 (RMS), the configuration leading to the smaller RMS is retained when 4 or more Dopplers are retained. If only three Dopplers are retained (4 such configurations) and if several of these 4 configurations (each using three Doppler counts) lead to residuals of less than 10 (RMS), all these configurations are retained.

This phase proves very effective in pointing out abnormal Dopplers and rejecting them. The introduction of the predicted value of the offset frequency forces the solution of the fix towards the true values. Experience shows that, if the offset frequency is left as an unknown in this first phase, the computation may converge towards a solution leading to small residuals, but completely errone ous both for position and offset frequency.

* <u>Second phase</u> - In the second phase, three unknowns are considered: longitude, latitude and offset frequency. The processing starts with the Doppler counts retained at the

end of phase 1 and the fix is accepted or rejected according to the agreement of the calculated value of the offset frequency with the predicted one. The fix is not accepted if the offset frequency differs by more than 0.2 cps from the predicted value, and a new iteration occurs considering all the solutions obtained by deleting one more Doppler count. As in the previous phase, if one or more configurations in the same iteration lead to acceptable fixes (offset frequency differing by less than 0.20 cps from the predicted one) the configuration leading to the smallest difference is retained only if more than 3 Dopplers are used. If the iteration considers 3 Doppler configurations and if several configurations satisfy the criterion, these configurations are kept and the fix is calculated as the average of the fixes retained.

Experience shows that deviations of 0.5 cps or more lead to erroneous fixes and that good fixes correspond to deviations of less than 0.2 cps. When the deviation exceeds 0.5 cps, the fix is rejected and an error message "offset frequency out of range" is pointed out.

* <u>Third phase</u> - No further Doppler editing is done in this phase which works on the last configuration (or configurations) accepted at the end of phase two.

a - The programme calculates the displacements of the fix in longitude and latitude (metres) for a variation of .2 knot of the East velocity of the ship, then for a

IDENTIFICATION DU PT 12 12 19 20 14 41 SAT. NO 14

SS DD HH MM Sat N°

means a 41° sat pass

FIXED DATA

7971520.0
3722258.0
571021.0
19680.0
5919.0
745449.0
956236.0
-518.0
13369.0
443055.0
999911.0

DOPPLER AND REFRACTION

3023445.0	1992.0
3137640.0	1999.0
3349343.0	2015.0
3687254.0	2013.0
4081000.0	2004.0
4391374.0	1999.0
4575582.0	2019.0
0.0	0.0

VARIABLE DATA

75.0	269.0	-2.0
89.0	259.0	-3.5
102.0	242.0	-5.0
114.0	219.0	-6.5
122.0	191.0	-8.0
128.0	160.0	-9.1
131.0	128.0	-10.0
130.0	96.0	-10.6
127.0	66.0	-11.0
119.0	40.0	-44.0
119.0	40.0	-44.0

LOCK-ON TIME=1916Z
ESTIMATED LATITUDE= -33.000 DEGREES
ESTIMATED LONGITUED= 156.000 DEGREES
COURSE= 270.000 DEGREES
SPEED= 8.400 KNOTS
ANTENNA HEIGHT= 160.000 FEET

FIG. 58

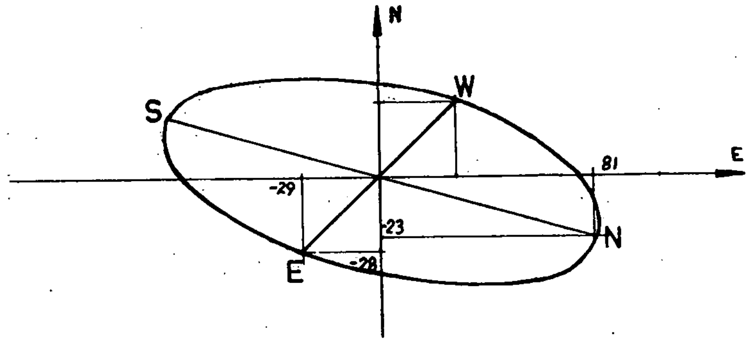
FIX CALCULATED AT POINT NO 3
DEG, MIN DECIMALES

32,50043S 156,20739E

DEG MIN SEC DEC

DEG, DECIMAUX

-32,83405 156,34565



FREQUENCE ENTREE 32054,10 FREQUENCE CALCULEE 32053,93
INPUT FREQUENCY CALCULATED FREQUENCY

COMPT,	RESIDUS RESIDUALS	ELEV.			AZIM.		
1							
2	-5,01472	9,4	A	16,9	319,9	A	307.1
3	7,71165	16,9	A	24,0	307,1	A	287.4
4	-3,14150	24,0	A	26,9	287.4	A	260.7
5	-1,83398	26,9	A	23,0	260,7	A	235.1
6	2,27899	23,0	A	15,7	235.1	A	217.0
7							
8							

	DELT, FREQ,	ECARTS VIT, NORD (+0,2 NOEUD) LONG	LAT	ECARTS VIT, EST (+0,2 NOEUD) LONG	LAT
VALEUR TYPE	0,20	90	30	30	20
VALEUR REELLE (REAL)	-0,17	-81	23	29	28

ANTENNA HEIGHT INCREASED BY 100 FEET,

DEG, MIN DECIMALES

32,50042S 156,20755E

DEG MIN SEC DEC

DEG, DECIMAUX

-32,83404 156,34592

FREQUENCE ENTREE 32054,10 FREQUENCE CALCULEE 32053,93

COMPT,	RESIDUS	ELEV.			AZIM.		
1							
2	-4,89851	9,4	A	16,9	319,9	A	307.1
3	7,58331	16,9	A	24,0	307.1	A	287.4
4	-3,17737	24,0	A	26,9	287.4	A	260.7
5	-1,67944	26,9	A	23,0	260,7	A	235.1
6	2,17236	23,0	A	15,7	235,1	A	217.0
7							
8							

	DELT, FREQ,	ECARTS VIT, NORD (+0,2 NOEUD) LONG	LAT	ECARTS VIT, EST (+0,2 NOEUD) LONG	LAT
VALEUR TYPE	0,20	90	30	30	20
VALEUR REELLE	-0,17	-81	23	29	28

FIG. 59

ANTENNA HEIGHT INCREASED BY 200 FEET,

DEG, MIN DECIMALES		DEG MIN SEC DEC	DEG, DECIMAUX	
32,500415	156,207716		-32,83402	156,34618

FREQUENCE ENTREE 32054,10   FREQUENCE CALCULEE 32053,94

COMPT,	RESIDUS	ELEV,			AZIM,		
1							
2	-4,78242	9,4	A	16,9	319,9	A	307.1
3	7,45538	16,9	A	24,0	307,1	A	287.4
4	-3,21311	24,0	A	26,9	287,4	A	260.7
5	-1,52503	26,9	A	23,0	260,7	A	235.1
6	2,06575	23,0	A	15,7	235,1	A	217.0
7							
8							

	DELT, FREQ,	ECARTS VIT, NORD (+0,2 NOEUD) LONG	LAT	ECARTS VIT, EST (+0,2 NOEUD) LONG	LAT
VALEUR TYPE	0,20	90	30	30	20
VALEUR REELLE	-0,16	-81	23	29	28

FIG. 60

variation of .2 knot of the North velocity.

Statistics on more than one thousand fixes at a fixed site show that generally satisfactory fixes lead to the following figures (metres RMS):

.2 knots North velocity, deviation East 90, deviation North 30
.2 knots East velocity, deviation East 30, deviation North 30

The fix is rejected and the error signal sensitivity out of range is printed out if the actual deviations exceed 175, 75; 75 and 75 metres respectively.

b - The programme calculates the displacement of the fix for variations in the antenna height above the geoid of 100 feet and 200 feet.

* <u>Particulars of the programme</u>-The programme introduces a correction for the tropospheric refraction improving the accuracy of fixes by some 25% and allowing for the use of low culmination angles. In actual fact, fixes culminating at 10 degrees are more accurate than fixes culminating at 65 degrees.

IV - I - 2. <u>Outputs</u>.

i. Printout (fig. 58 to 60)

The print out shows the configuration which has been retained, gives the residuals, the elevation angle at the beginning and at the end of each count as well as the azimuth, the deviation of the calculated offset frequency with respect to the predicted one, and the sensitivities in longitude and latitude for a variation of .2 knot of the North component of velocity and then for the East component.

The location is given at the 10 minute time closest to the centre of the Doppler count periods.

ii. Punched cards.

Time of satellite fixes, latitude and longitude are punched out in order to be used in the calculation of navigation (programme CALNAV).

IV - I - 3. Assessment

The print out allows for a discussion of the validity of the fix. The parameters analysed are:

- the symetry of the pass,
- the value of the residuals,
- the delta in frequency,
- the sensitivity in longitude and latitude for a variation of .2 knot of the North speed, then of the East speed.
- the magnitude of the variation of the parameters when antenna height is increased by 100 feet, then by 200 feet.

This assessment allows for the elimination of "poor"

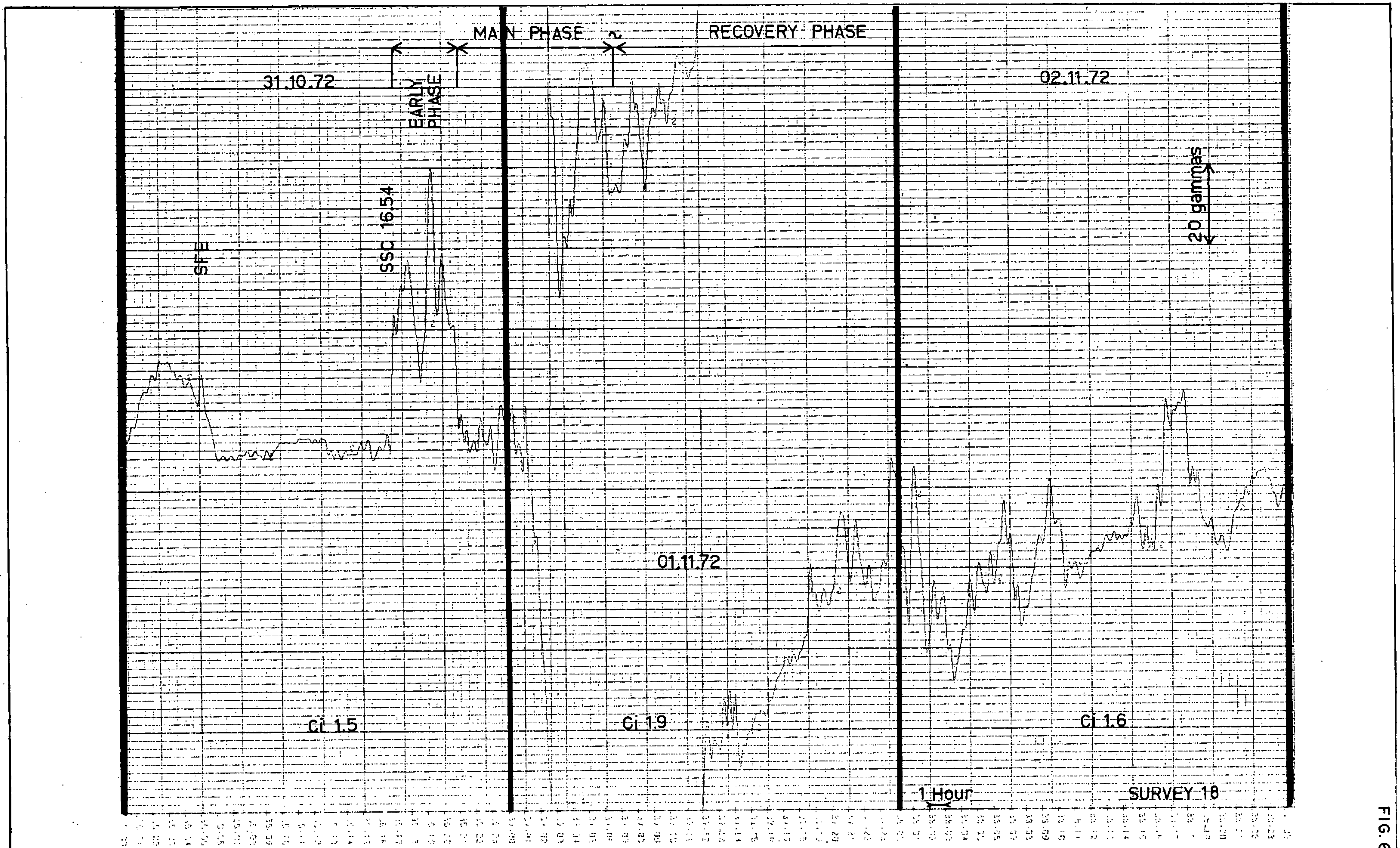
SHOMAG DIGITIZATION DATA CARDS

```
    XXXX.X
COMMENT. BMR DAY MULTIPLIED BY 24

     I  NNNNN.N
COMMENT.  I OR 2 IF I OR 2 SETS OF 9 CARDS OF 10 MINUTE VALUES
           NNNNN.N IS BASIC VALUE

 AAAA BBBB CCCC DDDD .... ETC
COMMENT.  I DAY OF 10 MINUTE VALUES CORRESPONDS TO 9 CARDS OF DATA
          THE VALUE RECORDED IS EQUAL TO NNNNN.N + AAAA .... ETC , MINUS MEAN OF
          QUIETEST DAYS
```

FIG. 61

FIG. 62

SURVEY / CRUISE	SHORE STATION	MEAN OF QUIETEST DAYS USED IN SHOMAG
05 / 1	PORT MORESBY	42983.4
05 / 2	PORT MORESBY	42983.4
05 / 3	PORT MORESBY	42983.4
05 / 4	PORT MORESBY	52983.4
05 / 5	PORT MORESBY	42983.4
10 / 1	PORT MORESBY	42983.4
11 / 1	HOBART	62660.9
11 / 2	HOBART	62660.9
12 / 1	EDEN	59803.2
12 / 2	COFFS HARBOUR	55785.0
12 / 3	COFFS HARBOUR	55785.0
12 / 4	COFFS HARBOUR	55785.0
13 / 1	COFFS HARBOUR	55785.0
13 / 2	MACKAY	50695.7
13 / 3	MACKAY	50695.7
13 / 4	MACKAY	50695.7
13 / 5	MACKAY	50695.7
14 / 1	MACKAY (2nd location)	50671.0
14 / 2	CAIRNS	47962.4
14 / 3	CAIRNS	47962.4
15 / 1	LAUNCESTON I	62142.4
15 / 2	LAUNCESTON I	62142.4
15 / 4	LAUNCESTON II	62196.8
16 / 1	LAUNCESTON II	62196.8
16 / 2	COFFIN BAY	59662.2
16 / 3	COFFIN BAY	59662.2
16 / 4	ALBANY	60253.4
17 / 1	ALBANY	60253.4
17 / 1	PERTH Observatory	58474.9
17 / 1	ONSLOW	53011.4
17 / 2	ONSLOW	53011.4
17 / 3	ONSLOW	53011.4
17 / 4	ONSLOW	53011.4
18 / 1	ONSLOW	53011.4
18 / 2	DARWIN	46431.1
18 / 3, 19 / 1	EMUPOINT	60415.5



SHOPLOT (MAGNETIC SHORE - STATION = DARWIN)

FIG. 63

satellites.

Note: The accuracy of the parameters introduced (heading and speed of the ship, frequency) is of vital importance for the subsequent quality of the fix.

IV - 2. DATA DIGITISATION

IV - 2 - 1 Shore station digitisation.

The creation of the final digitisation tape is made in several steps.

- Analogue records from the shore stations are digitised with values being taken every ten minutes (Data card format Fig. 61) and no hand-smoothing applied except for the noisy data of survey 13.
- A preliminary run of the programme SHOMAG fits a spline function through the complete set of data and thus obtains interpolated values at the one minute points both between the ten-minute samples and during any gaps.
- This preliminary run of SHOMAG also compute mean and standard deviation of magnetic quietest days values.

These values are taken from publications of International Service of Geomagnetic Indices (Kon. Nederl. Meteorol. Inst, DEBILD - The Netherlands). Mean used for each shore station is given if figure 62.

- A final run of the programme SHOMAG creates the tape required by the programme EOTMAG. The data on this tape is equal to the value of the magnetic field at the shore station minus the mean of the quietest days. Then, an assessment is performed by using the programme VARPLOT (Job SHOPLOT, fig. 63) to provide a plot at a very small scale ($^2/10"$=1H).If any corrections are required the data cards are changed and the processing, commencing with the final run of SHOMAG, is repeated.

IV - 2 - 2. Other Digitisations

As required, the Depth, Gravity and Magnetic analogue records were digitised utilising the following equipment -

- B.M.R. strip chart digitiser
- Lands Research Department of C.S.I.R.O strip chart digitiser
- Digitising table at C.S.I.R.O. Computing Department.

The creation of the final digitisation tape which will subsequently be sorted and input to the programme MISDAT was made in several steps.

- First the analogue records must be prepared and the details of the vertical and horizontal scales put onto punched cards.
- A punched tape is produced, by the digitisation of the records, which contains only the geometrical values (abscissae and ordinates) not the geophysical values. The tape may, optionally, be printed.
- The data on the punched tape is then transferred to the document region of the C.S.I.R.O. 3600 computer and edited as necessary utilising the C.S.I.R.O. programmes TED and FRED, which accept edit command from scopes.
- The programme PATRIC now combines the punched cards of

scales with the data and, using either a spline or linear interpolation technique, the one minute values are computed. The output from the programme is a printer listing with a plot on the line printer of selected parts of the data and a tape file of the complete data.

- Assessment of this data from the line printer output enables the production of any correction cards required. These cards are converted to the appropriate file format by the programme COMIT then both files are sorted and merged.

- The sorted file may either be fed directly to the programme MISDAT or if further assessment is required the programme DEPLOT is used to produce a printout of the values at ten minute intervals and, optionally, a file suitable for the programme VARPLOT to provide a plot. Any further correction cards necessary may be merged with the sorted file as were the original correction cards.

IV - 3. PLOT PROGRAMMES

Several plot programmes have been made available by the B.M.R to provide continuous chart plots for data assessment but the two most used were TWOPLOT and VARPLOT.
The programme TWOPLOT is an extended version of VARPLOT and provides plots from two input tapes for comparison purposes (usually the PRP tape and the CLEANUP tape as described in paragraph II.4)

The programme VARPLOT is used to plot

* PRP output
* MISDAT - MINIPLOT ouput
* GRANAV ouput
* SHOMAG ouput
* Special Gravity tapes from GRANAV and GRADED.

The options available in VARPLOT and TWO PLOT include

* plot scales
* ability to plot values unaltered
* ability to plot the differences between consecutive values
* ability to plot the incremented values.

A further plot facility is the drawing of current vector maps by the B.M.R from the CALNAV outputs for each main area of the Survey.

Finally, to get a quick check of data, a plot can be produced directly on the line printer together with the printout of actual values by means of the programme PLOP.

IV - 4. LISTING - PROGRAMMES.

Several programmes have been designed for a quick - look at selected data to enable rough checking etc.

* LISTCHANNEL: will provide a listing of any one channel of data at a selected interval and with the decimal point positioned as required. This programme will only accept phase I and II format tapes, except GRADED II output.

* PNCATCH will provide a listing that complements LISTCHANNEL by enabling up to ten channels to be printed simultaneously

but restricts the interval for the selection of the data.

* PNFIELD: will list the field tapes for surveys 17,18 and 19 as produced by the B.M.R. programme JOY.

* SEGLIST (a B.M.R programme) is provided to list the phase III tapes and GRADED II output.

APPENDICES

APPENDIX No. 1

CHANNELS ON OUTPUT TAPES

1. Field tape, and all output tapes of Phase I.

Channel 1	Time
Channel 2	Gravity
Channel 3	Cross coupling
Channel 4	Total correction
Channel 5	Spring tension
Channel 6	Magnetic
Channel 7	Sonar Doppler North/South
Channel 8	Sonar Doppler East /West
Channel 9	Chernikeeff Log
Channel 10	Pressure Log
Channel 11	Heading
Channel 12	Depth
Channel 13	Anemometer (front)
Channel 14	Anemometer (lateral)
Channel 15	Sine of the heading from the potentiometer
Channel 16	Cosine of the heading Sin. Cos.
Channels 17 to 24	VLF Phases
Channels 25 to 30	VLF amplitudes
Channels 31 and 32	nil

* On certain tapes both channels 13 and 14 are replaced by both 15 and 16.

* Channels 31 and 32 are used to save data (in PREVEW) if required.

Special output from MISDAT : MINIPLOT

Channel	1	Time
Channel	2	Gravity
Channel	3	Cross - coupling
Channel	4	Total Correction
Channel	5	Spring tension
Channel	6	Magnetic
Channel	7	Depth
Channel	8	Sum over 1 - minute Sonar Doppler N/S differences
Channel	9	Sum over 1 - minute Sonar Doppler E/W differences
Channel	10	Sum over 1 - minute of product of Chernikeeff Log differences and cosine of course
Channel	11	as 10 but sine of course
Channel	12	Sum of the product of 6 times the mean value of the pressure log difference for the 10 - minute block and the cosine of the course during the one minute
Channel	13	as 12 but sine of course
Channel	14	zero

2. Output from GRANAV.

* Tape 20

Channel	1	Time
Channel	2	Gravity
Channel	3	Cross - Coupling
Channel	4	Total Correction
Channel	5	Spring tension
Channel	6	Magnetic
Channel	7	Sonar Doppler North/South
Channel	8	Sonar Doppler East /West
Channel	9	Chernikeeff Log
Channel	10	Pressure Log
Channel	11	Heading
Channel	12	Depth
Channel	13	G after cross - correlation.
Channel	14	Magnetic without median filtering.
Channel	15	sine of heading from the potentiometer
Channel	16	cosine of heading Sin. Cos.

If median filtering made on magnetic, channel 6 contains filtered magnetic.

* Tape 35

Channel	1	Time
Channel	2	Gravity before cross - correlation (G)
Channel	3	correction trace (C)
Channel	4	Gravity after cross - correlation
Channel	5	(G-C) high frequency components
Channel	6	(G-C) low frequency components

Channel 7	C high frequency
Channel 8	C low frequency

C is either Total correction - 500 or cross - coupling - 500

3. Output from CALNA

* Tape 9

Channel 1	Time
Channel 2	Ratio latitude error/fix time interval system 1
Channel 3	Ratio longitude error/fix time interval system 1
Channel 4	Ratio latitude error/fix time interval system 2
Channel 5	Ratio longitude error/fix time interval system 2

4. Output from CALNAV

* Tape 9

  As for CALNA

* Tape 30

Channel 1	Time	
Channel 2	Sonar - Doppler	Latitude
Channel 3	Sonar - Doppler	Longitude
Channel 4	Chernikeeff Log	Latitude
Channel 5	Chernikeeff Log	Longitude
Channel 6	Pressure Log	Latitude
Channel 7	Pressure Log	Longitude
Channel 8	Heading	

Channel	9	Depth
Channel	10	Gravity
Channel	11	Cross - coupling
Channel	12	Total - correction
Channel	13	Spring - tension
Channel	14	Magnetic
Channel	15	Gravity after cross - correlation
Channel	16	Magnetic without median filtering.

If median filtering made channel 14 contains magnetic after filtering.

5. From SHOMAG

Channel	1	Time
Channel	2	Shore - Station data

6. From EOTMAG.

* TAPE INTER (FROM EOTMAG + GRADED I RUN)
* TAPE 20 (FROM EOTMAG RUN)

Channel	1	Time
Channel	2	Latitude (radian)
Channel	3	Longitude (radian)
Channel	4	Heading
Channel	5	Depth
Channel	6	Gravity
Channel	7	Cross - Coupling
Channel	8	Total correction
Channel	9	Spring tension

Channel 10	Magnetic
Channel 11	Gravity after cross - correlation
Channel 12	Magnetic without median filtering
Channel 13	Shore station magnetic
Channel 14	Eotvos
Channel 15	Gravity plus Eotvos (algebraic sum)
Channel 16	Magnetic - shore magnetic

7. From GRADED I

* Tape 20

Channel 1	Time
Channel 2	Latitude (degree)
Channel 3	Longitude (degree)
Channel 4	Depth (sign minus)
Channel 5	Gravity + Eotvos (algebraic sum or processing)
Channel 6	Magnetic
Channel 7	Shore magnetic
Channel 8	Gravity original

* Tape 25

Channel 1	Time
Channel 2	Gravity original
Channel 3	Eotvos
Channel 4	Gravity plus Eotvos (cross correlation)
Channel 5	Gravity high frequency components
Channel 6	Gravity low frequency components
Channel 7	Eotuos high frequency components
Channel 8	Gravity plus Eotvos (algebraic sum)

8. From GRADED II

Channel 1	Time
Channel 2	Latitude (degree)
Channel 3	Longitude (degree)
Channel 4	Depth (sign minus)
Channel 5	Gravity plus Eotvos
Channel 6	Magnetic
Channel 7	Shore magnetic
Channel 8 to 11	1.0 E10
Channel 12	B.C.D.

APPENDIX No. 2

LEAST SQUARE METHOD.

The purpose of this method is to fit through a set of points at regular interval the best straight line.

Let be p values $Y_1, Y_2, \ldots\ldots Y_p$

corresponding to abscissas $X_1, X_2, \quad X_p$ where $X_1 = \Delta$

$X_2 = 2\Delta$

$X_p = p\Delta$

What is the best fitting line $Y = aX + b$ passing through these points and the RMS between Y_i and this line.

The ordinals of the points of the best line for the given abscissas are

$\overline{Y}_1 = a\Delta + b$

$\overline{Y}_2 = 2a\Delta + b$

$\overline{Y}_p = pa\Delta + b$

The discrepancies between the given points and the points of the line are.

$$\left.\begin{array}{l} E_1 = Y_1 - \overline{Y}_1 = Y_1 - a\Delta - b \\ E_2 = Y_2 - \overline{Y}_2 = Y_2 - 2a\Delta - b \\ \text{-------------------------------} \\ E_p = Y_p - \overline{Y}_p = Y_p - pa\Delta - b \end{array}\right\} \quad \sum_{i=1}^{i=p} E_i^2 = \sum_{i=1}^{i=p} (Y_i - ia\Delta - b)^2$$

The best line is given by:

$$\frac{\partial(\sum E_i^2)}{\partial a} = 0 \text{ and } \frac{\partial(\sum E_i^2)}{\partial b} = 0$$

$$\begin{cases} \dfrac{\partial(\sum E_i^2)}{\partial a} = -2\Delta\left\{(Y_1 - a\Delta - b) + 2\,(Y_2 - 2a\Delta - b) + \ldots + p(Y_p - pa\Delta - b)\right\} \\ \dfrac{\partial(\sum E_1^2)}{\partial b} = -2\left\{(Y_1 - a\Delta - b) + (Y_2 - 2a\Delta - b) + \ldots + (Y_p - pa\Delta - b)\right\} \end{cases}$$

$$-\frac{1}{2}\frac{\partial(\sum E_i^2)}{\partial a} = 0 \Rightarrow \sum_{i=1}^{i=p} iy_i - \frac{p(p+1)}{2} b - a\,\Delta \sum_{i=1}^{i=p} i^2 = 0$$

$$-\frac{1}{2}\frac{\partial(\sum E_i^2)}{\partial b} = 0 \Rightarrow \sum_{i=1}^{i=p} Y_i - pb - a\frac{\Delta p(p+1)}{2} = 0$$

Therefore the linear system giving a and b is:

$$\begin{cases} \Delta\sum i^2 \,.a + \dfrac{p(p+1)}{2}\,.b - \sum iY_i = 0 \qquad \begin{matrix} i=p \\ i=1 \end{matrix} \\ \Delta\dfrac{p(p+1)}{2}\,.a + p.b - \sum Y_i = 0 \end{cases}$$

The second equation is equivalent to $\sum E_i = 0$

Hence

$$b = \frac{\sum_{i=1}^{i=p} Y_i \sum_{i=1}^{i=p} i^2 - \sum_{i=1}^{i=p} iY_i \quad \frac{p(p+1)}{2}}{p\sum_{i=1}^{i=p} i^2 - \frac{p^2(p+1)^2}{4}}$$

$$a = \frac{\frac{p(p+1)}{2}\sum_{i=1}^{i=p} Y_i - p\sum_{i=1}^{i=p} iY_i}{\frac{\Delta p^2\,(p+1)^2}{4} - p\,\Delta\sum_{i=1}^{i=p} i^2}$$

if $p = 4$ and $\Delta = 1$

$$b = Y_1 + 0.5\ Y_2 - 0Y_3 - 0.5Y_4$$

$$a = \frac{-3}{10} Y_1 - \frac{1}{10} Y_2 + \frac{1}{10} Y_3 + \frac{3}{10} Y_4$$

The predicted value is equal to

$$\overline{Y}_5 = 5a + b$$

$$\overline{Y}_5 = -0.5\ Y_1 + 0Y_2 + 0.5\ Y_3 + 1\ Y_4$$

APPENDIX No. 3

MOVING MEDIAN AND AVERAGE

* Separation of high and low frequency periods on a trace can be made by using a moving median filtering followed by a moving average (which constitutes a non-linear filtering). Effect of median, average and median + average filter are successively described in this appendix.
Both filter used have a window of 17 points, i.e. 170 seconds.

* Figure 64 shows the effect of a median plus averaging processing on noisy data.

1. Median filter. (Fig. 10, 12A)

The median of a set of measurements is defined as the middle measurement, if there is one, after the measurements have been arranged in order of magnitude.
The response curve has been obtained by submitting sinusoid of various period (from 50s to 10 minutes by increments of 50 seconds; i.e. 12 sinusoids) into a median filter. The curve obtained (fig.12A) gives the following information.

* The low frequencies contain 45% of 4-minute components of the original trace
* The low frequencies contain 58% of 5-minute components of the original trace
* The low frequencies contain 74% of 6-minute components of the original trace

EFFECT OF MEDIAN FILTER ON SEVERAL SINE FUNCTIONS

PERIOD : 6 = 1 MINUTE

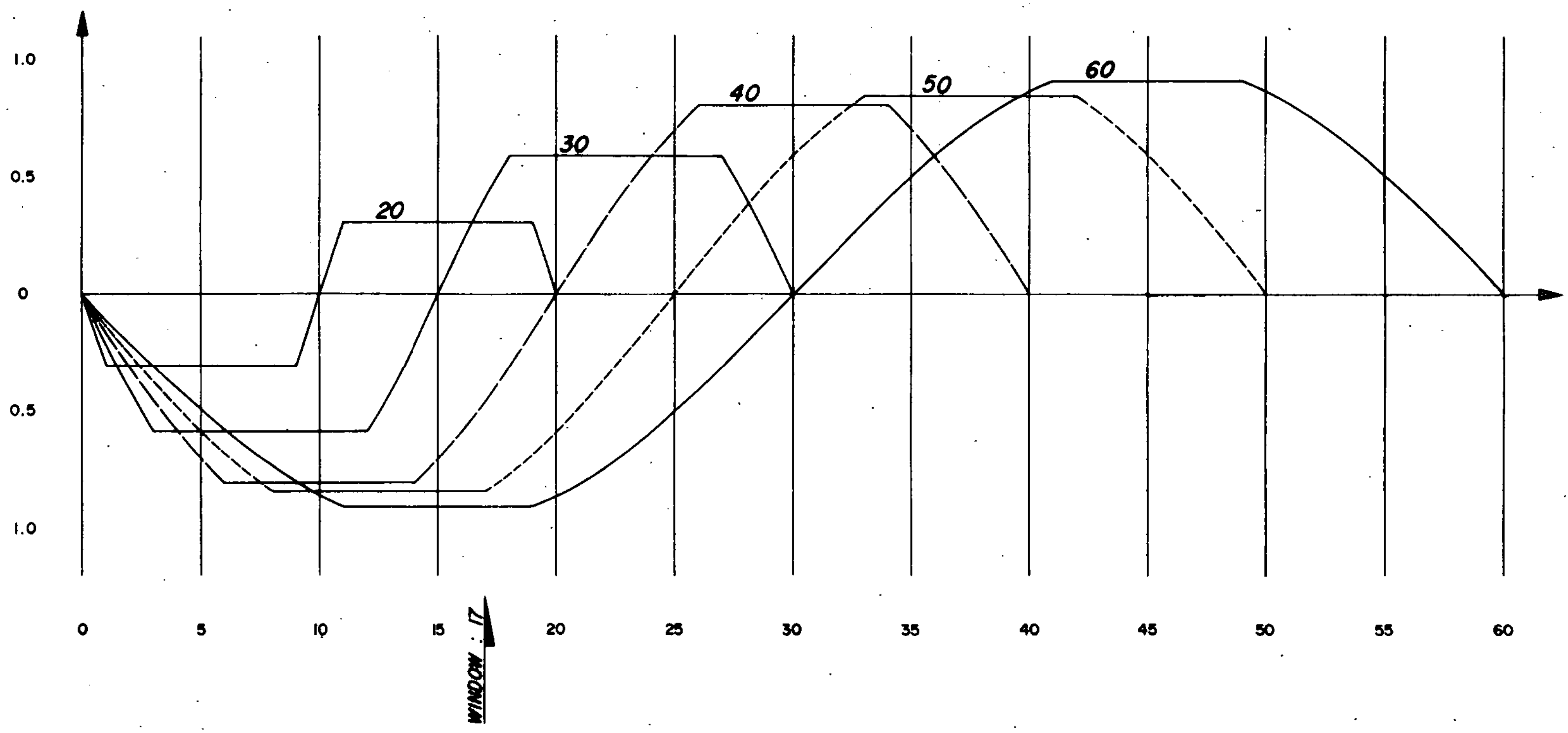


FIG. 10

EXPERIMENTAL RESPONSE CURVES

for : MEDIAN FILTERING
AVERAGE FILTERING
MEDIAN + AVERAGE FILTERING

PERIOD : 6 = 1 MINUTE

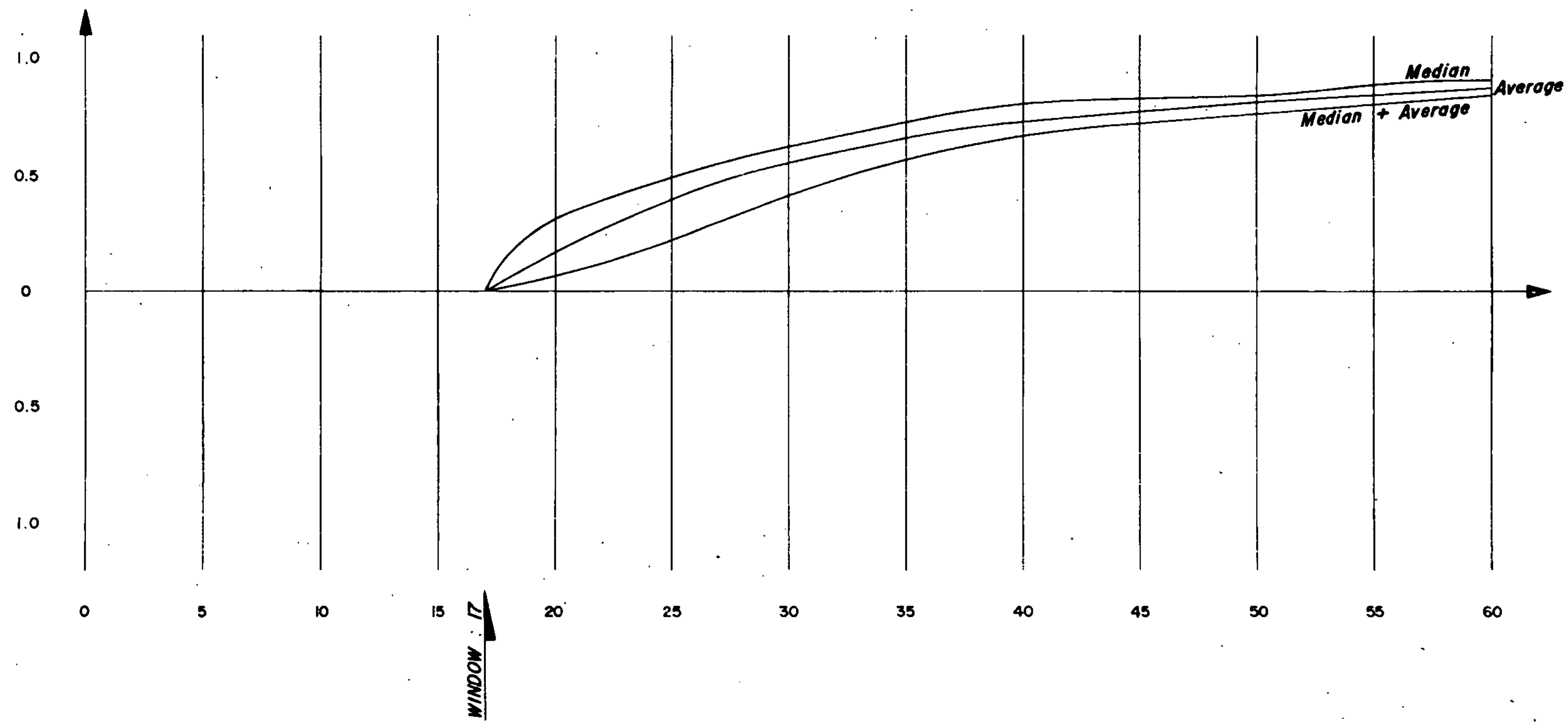


FIG. 12 A

* The low frequencies contain 92% of 10-minute components of the original trace

It must be noted that median filtering is not a linear function. Thus it is difficult to extrapolate the results obtained on some sinusoids to any curve whatever, except in the case of an isolated phenomena for which the figures obtained do still apply.

Figure 10 shows the effect of median filter on several sinusoids.

2. Average filter.

The theoretical response curve of the averaging filtering is given by the formula

$$\frac{A_o}{A_i} = \frac{\sin l f \Pi}{l \sin f \Pi} = \frac{\sin \frac{l}{p} \Pi}{l \sin \frac{\Pi}{p}}$$

where A_o = output amplitude

A_i = input amplitude

l = window size = 17 points

f = frequency in cycles/step

p = period in steps.

In our case = $\frac{A_o}{A_i} = \frac{\sin 17 f\Pi}{17 \sin f\Pi} = Y$

$$Y' = \frac{17\,\Pi \cos 17 f\Pi \, . \sin f\Pi \; - \; \Pi \sin 17 f\Pi \; . \cos f\Pi}{17 (\sin f\Pi)^2}$$

for $f < \frac{1}{17} \Longrightarrow Y'>0$

$\Longrightarrow$ Y is a increasing function in this interval.

for $f = \frac{k}{17} \quad k \in \mathbb{N} \Longrightarrow Y = 0$

EFFECT OF THE AVERAGE FILTER ON SEVERAL SINE FUNCTIONS

PERIOD : 6 = 1 MINUTE

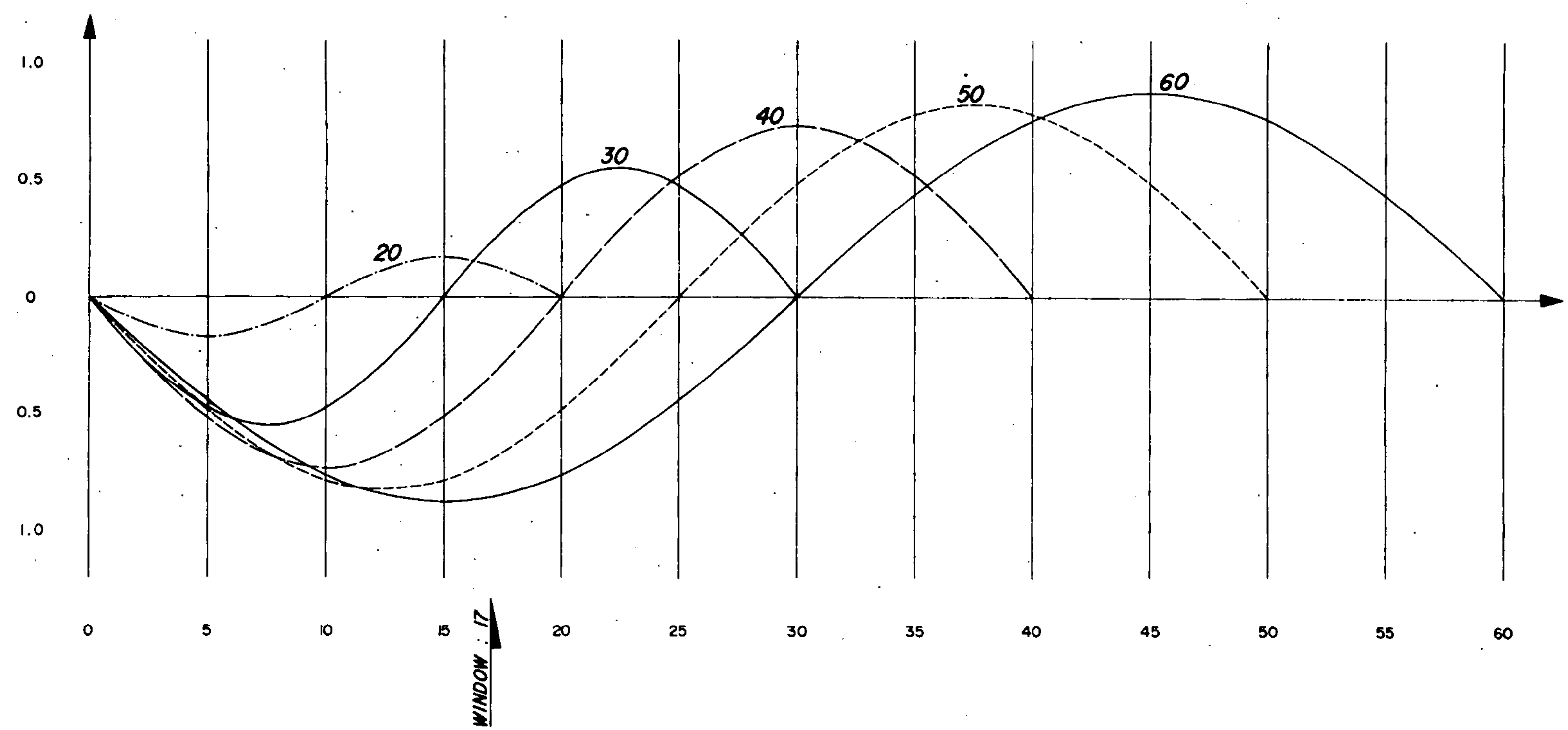


FIG. 9

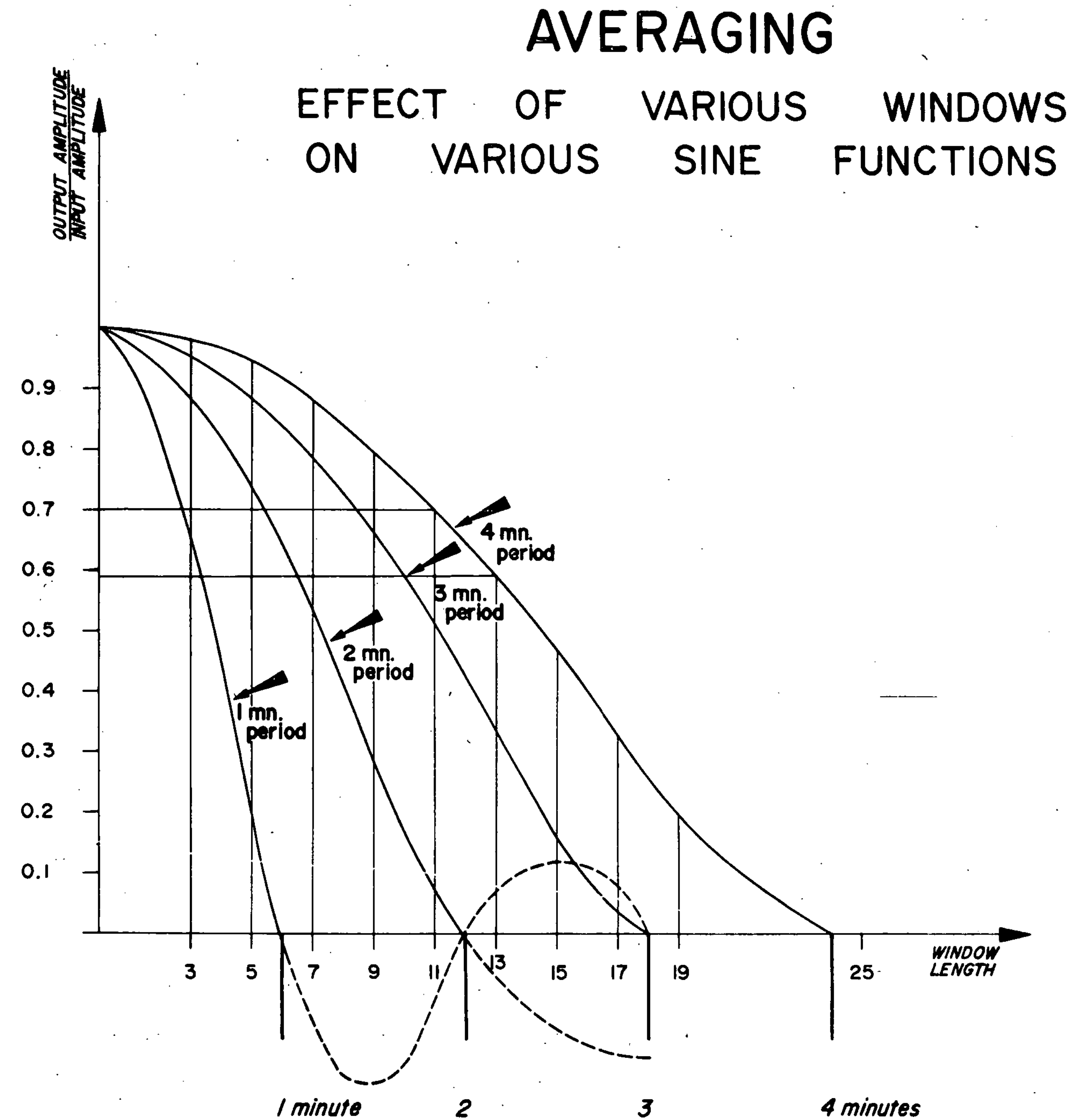

AVERAGING
EFFECT OF VARIOUS WINDOWS
ON VARIOUS SINE FUNCTIONS
OUTPUT AMPLITUDE / INPUT AMPLITUDE
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4 mn. period
3 mn. period
2 mn. period
1 mn. period
3
5
7
9
11
13
15
17
19
25
WINDOW LENGTH
1 minute
2
3
4 minutes

FIG. 12 B

The corresponding curve is given in figure 12A; for a clearer picture, these are the periods which have been expressed on the abscissas. The curve obtained gives the following information:

* The low frequencies contain 35% of the 4-minute components of the trace
* The low frequencies contain 55% of the 5-minute components of the trace
* The low frequencies contain 70% of the 6-minute components of the trace
* The low frequencies contain 88% of the 10-minute components of the trace

It must be pointed out that the average filter is a linear filter. Figure 9 shows the effect of average filter on several sinusoids, Figure 12B shows the effect of average filter for phenomena of various period according to the window of the average filter.

3. Median plus Average filter.

The experimental curve of the median + average filtering has been obtained by the method described in paragraph 1. The curve obtained gives the following information (fig. 11)

* The low frequencies contain 20% of the 4-minute components of the trace
* The low frequencies contain 41% of the 5-minute components of the trace

EFFECT OF MEDIAN AND AVERAGE FILTER ON SEVERAL SINE FUNCTIONS

PERIOD : 6 = 1 MINUTE

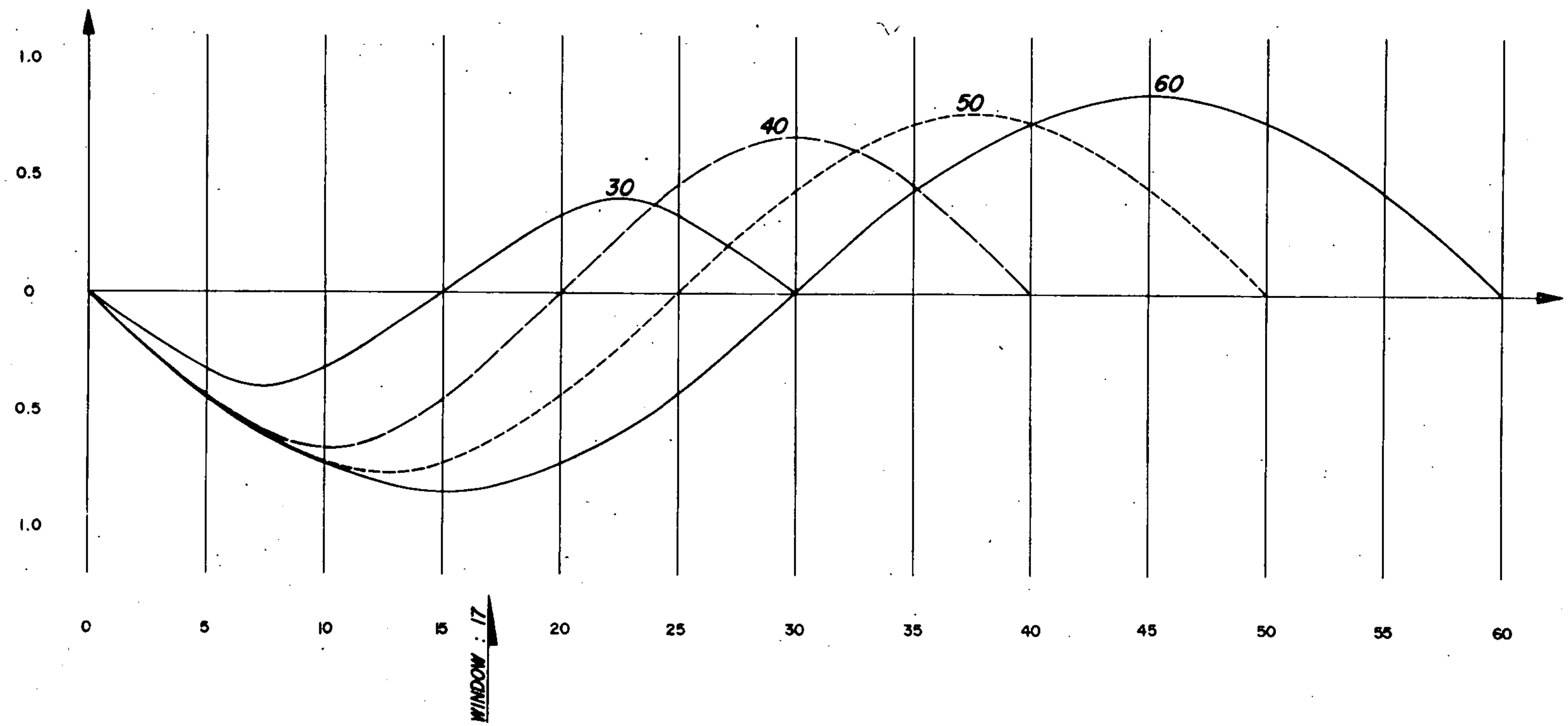
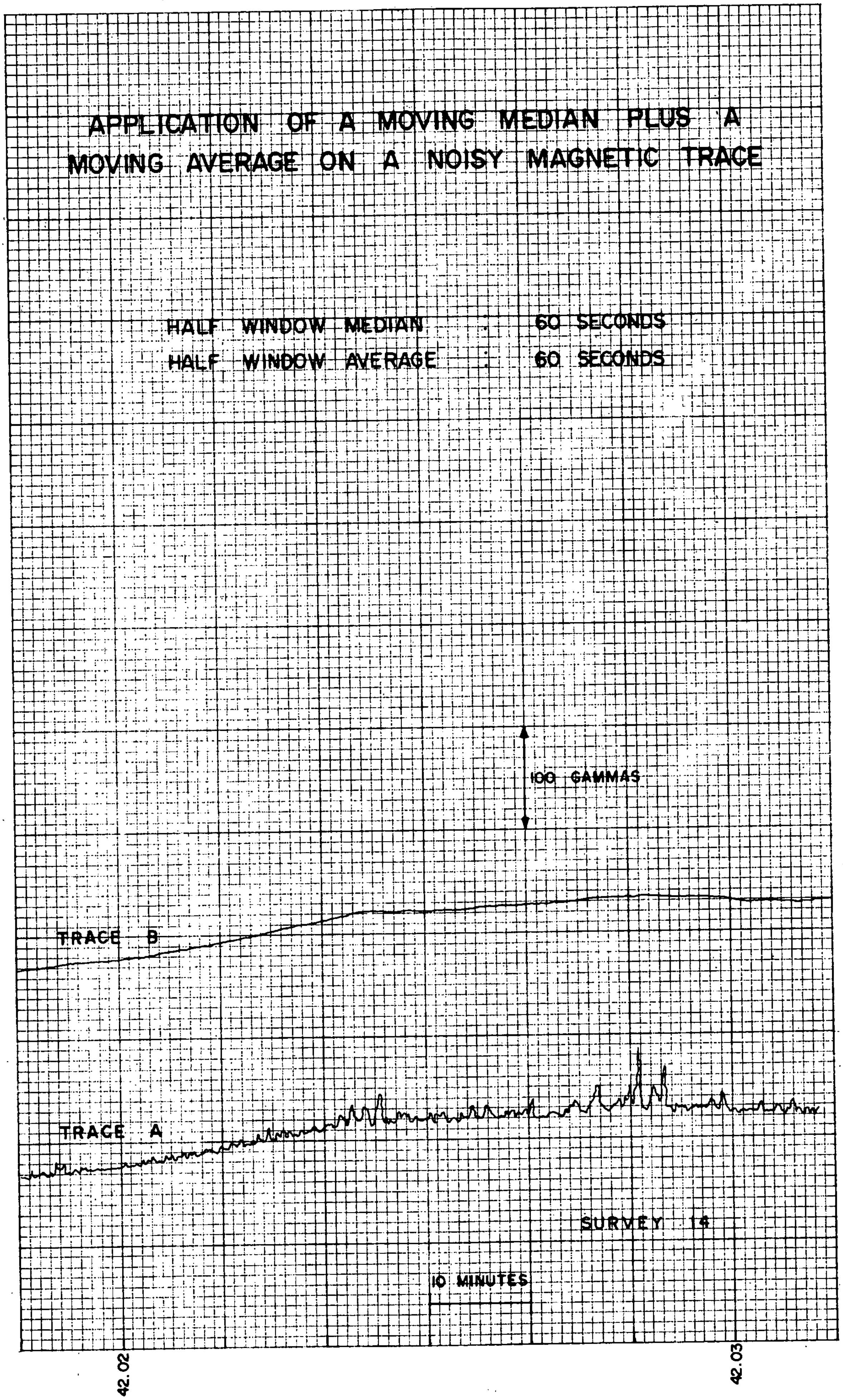


FIG. 11

FIG. 64


APPLICATION OF A MOVING MEDIAN PLUS A
MOVING AVERAGE ON A NOISY MAGNETIC TRACE
HALF WINDOW MEDIAN : 60 SECONDS
HALF WINDOW AVERAGE : 60 SECONDS
100 GAMMAS
TRACE B
TRACE A
SURVEY 14
10 MINUTES
42.02
42.03

* The low frequencies contain 60% of the 6-minute components of the trace
* The low frequencies contain 85% of the 10-minute components of the trace

4. Application to noisy data.

Figure 64 shows the effect of a moving median followed by a moving average on a noisy magnetic trace. Half window for both processes was 6 points, i.e. 60 seconds.

APPENDIX No. 4

CROSS - CORRELATION

I. JUSTIFICATION OF THE PROCESSING

The gravity value shown on a LaCoste and Romberg gravity meter is derived from 8 different components

1. the spring tension ST
2. the term K x dB/dt proportional to the velocity of the beam
3. the inherent cross-coupling or VCC which is a function of : X" x Z' and Y" x Z'
4. The long imperfection cross coupling function of X" x Z"
5. the cross imperfection cross coupling function of Y" x Z"
6. the vertical error=function of Z''^2
7. The horizontal error = function of X''^2
8. the horizontal error = function of Y''^2

dB/dt, or the angular velocity of the beam, is proportional to Z" and therefore the deviation of the beam with respect to the horizontal is proportional to Z'

X" and Y" being the horizontal accelerations along the long (X) axis and the cross axis (Y) respectively - they are derived from the output voltages of the two accelerometers placed on the stable platform.

Z" is the vertical acceleration, or more exactly the short period part of the vertical acceleration, it is obtained as a voltage derived from the beam position B.

Basically three analog outputs or voltages are used to build up the component terms of the gravity value in a LaCoste Romberg meter:

1. The Z' or B, beam position
   a differentiating circuit produces the dB/dt term proportional to Z"
2. the X" or long axis acceleration
3. the Y" or cross axis acceleration

The first problem is to define the correct calibration constants necessary to convert the output voltages into the correct accelerations, Z" X" and Y"

The term Z' is in fact proportional to the beam angle with respect to the horizontal and in the cross coupling (VCC) term, it is the beam angle which is used. This would lead to a definition of 4 constants in order to calibrate the four output signals.

In the LaCoste and Romberg meter, the error analysis introduces constructional errors (geometrical imperfection errors) as well as errors relating to the principle of the meter (inherent cross coupling)

Dr LaCoste points out in his paper "Gravity measurement at sea and in the air" 1967 that G may be considered as the sum of the following terms

$G = ST + K1 \times dB/dt + e$

where $e = a_1 X''^2 + a_2 Y''^2 + a_3 Z''^2 + a_7 X''Z' + a_8 Y''Z' + a_9 X''Z'' + a_{10} Y''Z''$

the terms a_i being constants defined experimentally for each meter by LaCoste and Romberg.

- The inherent cross coupling equals a_7 X" Z' + a_8 Y" Z' . This expression of the inherent cross coupling accounts for construction imperfections of the meter as Y" should not intervene for a theoretical meter
- The long imperfection cross coupling is equal to a_9 X"Z" and the cross imperfection cross coupling is equal to a_{10} Y" Z"

It should be noted that the calibration of the cross coupling terms, because of the geometrical imperfection of the meter, is only valid for a certain range of horizontal accelerations; for large horizontal accelerations, the meter is distorted, according to the accelerations, while the terms defined by LaCoste are "static" imperfection terms and do not account for periodic distortion of the meter under variable horizontal constraints.

The approach taken by Dr LaCoste in his paper: Cross correlation method for evaluating and correcting shipboard gravity data consists in considering the above mentioned a_i factors as constants. These constants may be defined by zero cross correlation methods if one considers that the final gravity should show no correlation with factors related to ship's motion, that is to say the terms including X" Y" or Z" , or merely the components of e.

The major conclusion is that the actual calibration of the different terms affecting the computation of G in a LaCoste and Romberg meter may differ substantially from the calibration given by the manufacturer. This had been pointed out as far as 1969 by CGG.

Very often, the gravity trace showed considerable correlation with the Total cross coupling trace and CGG's approach was to adapt the cross coupling correction, both in phase and in amplitude, so that the corrected gravity should not correlate with the cross coupling correction, at least for short period events of less than 3 minutes.

The TRITON processing was applied in order to cope with that problem. In our opinion, it does the same thing as does the processing proposed by Dr LaCoste as long as horizontal accelerations are not such as to distort the geometry of the meter. When geometrical distortion appears, the processing proposed by Dr LaCoste is no longer valid, as the "constant" terms a_i do vary, while the TRITON processing follows the variations of these terms. There is, of course a limit as too much distortion in the meter leads to non linearity and large errors. This is in fact what was observed very often when sea condition deteriorate with waves exceeding from 7 to 10 feet depending of the particular meter.

The same processing was tried using gravity and the high frequency part of the Total correction, which includes the term e, plus the K x dB/dt term. Of course the term K dB/dT should show correlation with gravity as it is part of it. On a moving ship, the Eotvos correction does not vary very abruptedly, so that there is no reason for the gravity to correlate with high frequency components of the TOTAL CORRECTION, high frequency meaning in this particular case periods shorter than those pointed out by the Eotvos correction, generally less than 5 minutes. This approach is more complete than the preceding one (Triton applied to the Total cross coupling only) as it takes care of the X''^2 Y''^2 and Z''^2 terms.

Considerable improvement was observed on many shipborne gravity surveys using either the TRITON processing with the total cross coupling or with the high component of the Total correction.

II. THEORY OF THE PROCESSING

II.1 Application of the TRITON procedure to the correction for total cross-coupling

The introduction to this note demonstrated the necessity of using Triton processing to carry out the correction for total cross coupling. This processing procedure will be described in this section. A more accurate description is given in the paragraph II.2. It should be remembered that the correlation between the gravity trace and total cross coupling is often quite strong, despite the fact that this should only be an accidental phenomenon.

The aim of the Triton procedure is to adjust the total cross coupling, in phase and amplitude, so that gravity and correction no longer have a general correlation. It should be remembered that, in order to adapt the correction properly, the parameters which characterise it must change with the time.

Before turning to the main problem, we will consider the Triton procedure in the simple case when all that is necessary is to adjust the correction as a whole, i.e. when it is not necessary to adjust the trace and the correction in a way which changes with the time. Let us consider a trace in the form: $Y(t) = Y_1(t) + \gamma X(t)$, $Y_1(t)$ and $X(t)$ being two functions which have no correlation, γ being a positive constant. Let us suppose that $Y(t)$ and $X(t)$ (fig. 65) are known to a time shift δ , i.e. let us assume that the function $X'(t) = X(t+\delta)$ is known. The two unknown parameters γ and δ can be determined in two steps:

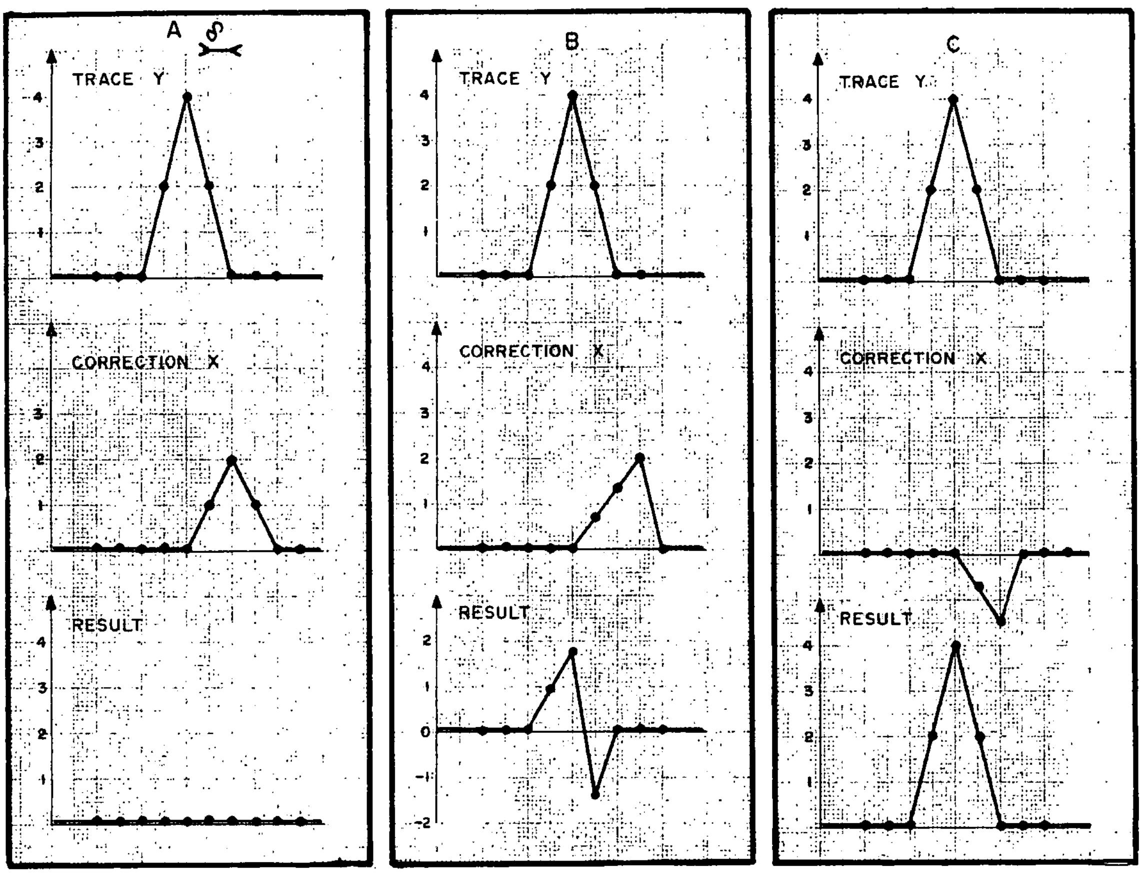
- δ is the shift which makes the correlation between $Y(t)$ and $X'(t-\delta)$ reach its maximum; this correlation calculated for values between two limits $-\delta_{MAX}$, and $+\delta_{MAX}$, fixed beforehand.

- If δ is known, $X(t)$ can be calculated. Hence the evaluation $\bar{\gamma}$ of γ can be deduced:

$$\bar{\gamma} = \frac{\sum XY}{\sum X^2}$$

Let us suppose that $\bar{\gamma} = 0$ if $\sum XY$ is negative or if $\sum X^2 = 0$.

FIG. 65



	A						
1	-1	0	1	2	3	4	5
2	0	2	8	12	8	2	0
3	6						
4	0	0.16	0.66	1	0.66	0.16	0
5	0	0.33	1.33	2	1.33	0.33	0

	B							
1	-2	-1	0	1	2	3	4	5
2	0	0	1.33	5.33	10.66	6.66	4	0
3	6.22							
4	0	0	0.11	0.43	0.87	0.54	0.32	0
5	0	0	0.21	0.86	1.71	1.07	0.64	0

	C							
1	-2	-1	0	1	2	3	4	5
2	0	0	-4.5	-6	-7.5	-3	0	0
3	2.81							
4	0	0	-0.54	-0.73	-0.91	-0.36	0	0
5	0	0	<0	<0	<0	<0	0	0

1 δ 2 Σxy 3 Σx^2 4 $\frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$ 5 $\frac{\Sigma xy}{\Sigma x^2}$

δ : Shifts

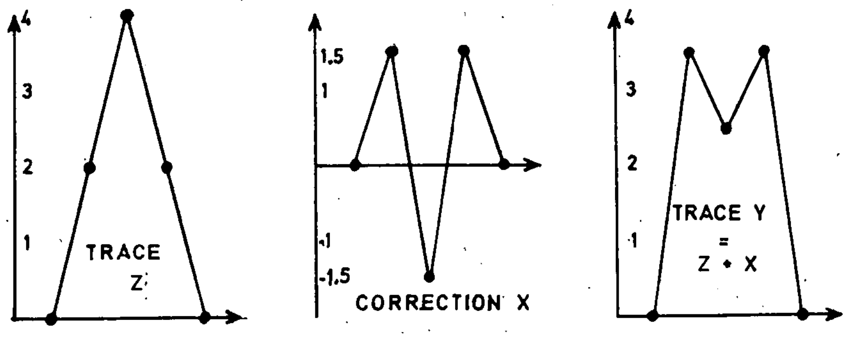
$\frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$: Correlation coefficient (r)

$\frac{\Sigma xy}{\Sigma x^2}$: Regression coefficient (γ)

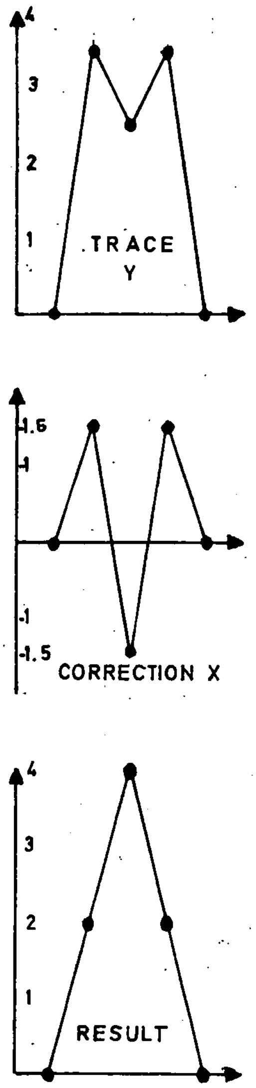
NOTE : ONE CAN VERIFY FOR THE DIFFERENT SHIFTS USED $Y - \gamma X$ AND X DO NOT CORRELATE

EXAMPLE OF CROSS-CORRELATION PROCESSING PERFORMED FOR THREE SIMPLE CASES

CREATION OF THE EXAMPLE



CROSS CORRELATION PROCESSING



1	- 2	−1	0	1	2
2	5.25	−1.5	6.75	−1.5	5.25
3	6.75				
4	0.36	-0.1	0 47	−0.1	0.36
5	0.78	<0	1	<0	0.78

Z UNCORRECTED TRACE

X CORRECTION TRACE

Y CORRECTED TRACE Z+X

$$\gamma = \frac{\Sigma(Z_i + \lambda X_i)X_i}{\Sigma X_i^2}$$

WHEN Z AND X DONOT CORRELATE , $X_i Z_i = 0$ AND $\lambda = \gamma$

THE ABOVE EXAMPLE WHERE Z AND X PRESENT A NULL CORRELATION COULD REPRESENT AN ANOMALY DISTORTED BY THE CORRECTION

Of course, the better the non-correlation hypothesis between X and Y_1, the nearer this evaluation $\overline{\gamma}$ will be to the true value of γ.

To return to the original problem, i.e. that the adaptation of the correction should vary with time, the functions $\gamma(t)$ and $\delta(t)$ must be determined. The method used consists of applying the procedure that we have just described in a moving window. More accurately, $\gamma(t)$ and $\delta(t)$ are calculated in a window which includes t; then the trace is corrected to time t:

$$TC(t) = T(t) - \gamma(t)\ TT(t+\delta(t))$$

In this formula, T is the gravity before correction, TT the total cross coupling correction, and thus TC is the trace corrected for cross coupling.

Two parameters intervene in the evaluation of $\gamma(t)$ and $\delta(t)$:

- <u>the width of the calculating window</u>

The shorter the window used, the better able the procedure is to follow a time variation in the parameters γ and δ. However, if the window is short, the gravity anomalies which have a correlation with the cross coupling might be reduced too much (in particular, a window reduced to a point would result in a correction trace which would vanish identically).

- <u>the maximum time shift</u> δ MAX : $|\delta| \leq \delta$ MAX

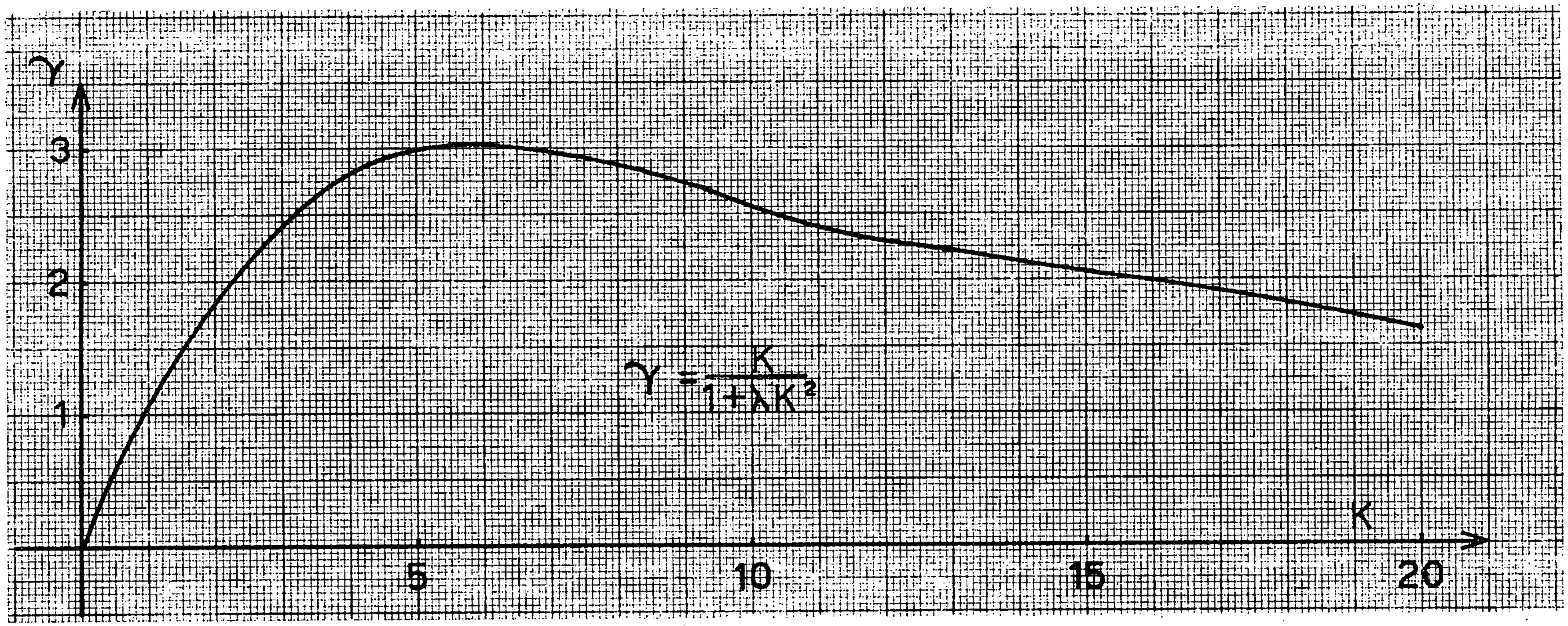
Since the trace and the correction are in the aggregate adjusted in time, δ must be sought between the limits $-\delta_{MAX}$ and $+\delta_{MAX}$. δ_{MAX} should be neither too small so that it is possible to compensate for possible time shifts between trace and correction , nor too large in order to avoid eliminating real anomalies as far as possible. Of course, with any given anomaly, it is always possible to find a portion of cross coupling which has a certain correlation with this anomaly.

In view of the results of the processing described above, we have improved the method in two ways.

- <u>By introducing a threshhold on</u> γ: $\gamma \leq \gamma$ MAX

Since the trace and correction are at approximately the same scale, the values of γ cannot be far from 1; thus, γ must be within certain limits. We have already fixed the lower limit of γ at 0, which means that we can ignore the correction when it has a negative or zero correlation with the trace; this occurs on noisy parts of data gathered. The fact that γ has a set upper limit ($\gamma \leq \gamma_{MAX}$ with γ_{MAX} = 3 for example), makes it more improbable that anomalies which have a correlation with the correction will be eliminated; this becomes impossible if the correction is small in comparison with the trace.

There are two possible methods of limiting the values of γ .



LIMITATION CURVE OF γ

FIG. 66

. the first consists of replacing the calculated values of γ which are higher than γ_{MAX} by γ_{MAX}.

. the second method, which is the one that we have adopted, is to modify the formula of γ so that the values of γ are limited gradually (Fig. 66).

- Smoothing the $\delta(t)$ curve

Up to now, we have supposed that δ had a law of probability which was a priori uniform over the interval $(-\delta_{MAX}, +\delta_{MAX})$, i.e. that γ had a zero probability outside this interval, and that all the values of γ were equally probable between the limits $-\gamma_{MAX}$ and $+\gamma_{MAX}$. It is preferable to choose a law of probability P_t which:

- on the one hand, makes large time shifts gradually less probable. Hence, the choice of γ_{MAX} is less arbitrary.
- on the other hand, changes gradually with the time so that the $\delta(t)$ curve is smooth. More accurately, the law P_t will be more favourable at time t to shifts near $\delta(t-1)$.

Finally, let us point out that there is no question, in using the cross coupling, of adjusting the slow variations phenomena, since this phenomena should be eliminated beforehand by filtering, with a moving median, for example, both from the trace and from the correction. These slow variations phenomena will be reintroduced after Triton.

II.2. Theory.

Given two traces X and Y, length n. The regression coefficient γ of Y on X is the value γ of the parameter α which minimizes the expression:

$$\sum_{1 \leq i \leq n} (Y_i - \alpha X_i)^2$$

Derivation will yield:

$$\gamma = \frac{\sum X_i \; Y_i}{\sum X_i^2}$$

One can verify that Y - γX and X do not correlate.

For a given trace T and a correction trace TT, the aim of the TRITON procedure is to locally adjust the amplitude of the correction in such a way that the corrected trace is the smallest possible. The correction of the point of abscissa x is accomplished by the determination of the coefficient γ (x) between two windows F and F' centered on x of the traces T and TT.

$$TC_{(x)} = T_{(x)} - \gamma \; TT_{(x)}$$

is then calculated

TRITON with shift.

When the phenomenons present a phase shift, the window F' which correlates with the window F has to be determined prior to the calculation of γ .

F' is centered on x'

$$TC(x) = T(x) - \gamma(x)\ TT(x')$$

is then calculated.

Determination of F' : if $\Gamma(\delta)$ is the intercorrelation function between F and several F' shifted by δ samples, then the shift $\bar{\delta}$ which correspond to Γ maximum is chosen.
The function Γ is calculated for:

$$-\delta_{MAX} \leq \delta \leq \delta_{MAX}$$

When the signal to noise ratio is small, the shift $\bar{\delta}$ is not accurately determined and the curve $\delta(x)$ lacks in continuity. This leads to weight the curve $\Gamma(\delta)$ so as to satisfy the two following conditions:

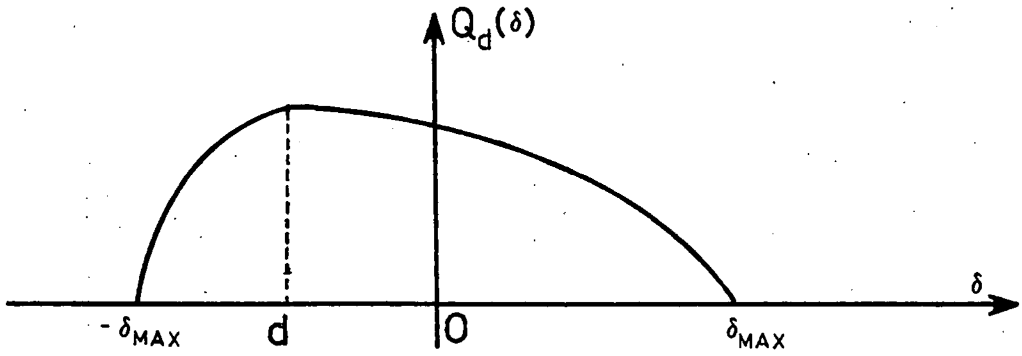
a - the curve $\bar{\delta}_{(x)}$ must be continuous, this is realized by means of a weighting which aims to obtain $\bar{\delta}_{(x)}$ very close to $\bar{\delta}(x-1)$.

b - $\bar{\delta}_{(x)} = 0$ which means that the weighting will favour the small shifts.

One defines the curve $Q_d(\delta)$:

$$Q_d(\delta) = -\frac{(\delta-d)^2}{(\delta_{MAX}+d)^2} + 1 \qquad \text{for} \quad \delta \leq d$$

$$Qd\ (\delta) = -\frac{(\delta-d)^2}{(\delta_{MAX}-d)^2} + 1 \qquad \text{for} \quad \delta \geq d$$



The curve $P(\delta) = Q_o(\delta) \times Q_{\overline{\delta}(x-1)}(\delta)$ constitutes the desired answer to the weighting of the intercorrelation function $\Gamma(\delta)$
The shift $\overline{\delta}(x)$ sought corresponds to the maximum of the expression: $\Gamma(\delta) \times P(\delta)$.

<u>TRITON with condition $0 \leq \gamma \leq \gamma_{MAX}$.</u>

γ must be such that the expression:

$$\sum(f-\gamma g)^2 + \lambda^2 (\sum f^2)\gamma^2 \text{ be minimum.}$$

The effect of the term $\lambda^2(\sum f^2)\gamma^2$ is to limit γ.

Derivation yields

$$\gamma = \frac{\sum fg}{\sum g^2 + \lambda^2 \sum f^2}$$

Let γ be 0 . (if $\sum fg < 0$)

When γ is maximum, then f will be in the form f=kg; in this case:

$$\gamma = \frac{K}{1+\lambda^2K^2}$$

The extremums of this function K are obtained for $K=\pm\frac{1}{\lambda}$

The maximum value of γ is: $\gamma_{MAX} = \frac{1}{2\lambda}$, from which is deduced the value of $\lambda = \frac{1}{2\gamma_{MAX}}$ when γ_{MAX} is given.

In Fig 66, the curve $\gamma(K)$ is drawn (for $\gamma_{MAX} = 3$). It will be noticed that:

- γ is close to 1 for K = 1
- γ =0 if K = 0
- γ decreases when K is large.

III PARAMETERS USED IN PRODUCTION WORK.

i. GRANAV cross correlation

* From Survey 05 to Survey 15:

Half separation windows high frequency:

24 points ≡ 240 seconds.

Half correlation window:

16 points ≡ 160 seconds.

Time Shift:

8 points ≡ 80 seconds.

* From Survey 15 to Survey 19.

Half high frequency separation window:

14 points ≡ 140 seconds.

Half correlation window:

10 points ≡ 100 seconds.

Time Shift:

6 points ≡ 60 seconds.

ii. <u>GRADED I cross correlation and turn error removal</u>.

* Cross correlation.

Half high frequency separation window:

5 points ≡ 5 minutes

Half correlation window:

5 points ≡ 5 minutes

Time Shift:

3 points ≡ 3 minutes.

* Turn error removal.

Half "seeking a turn" window:

5 points ≡ 5 minutes.

Half "interpolation at a turn" window:

5 points ≡ 5 minutes.

Threshold:

5 milligals.

APPENDIX No. 5

WORKING START AND STOP.

Official "Start" and "Stop" of work do not always correspond to satellite fixes; hence the necessity to compute "dummy fixes" from existing data, in the following way =

- let time T_1 be last satellite fix before official start
  - satellite location at this time: S_1 lat S_1 long
  - Doppler values at this time: D_1 lat D_1 long
- let time T be official Start
  - Ship position (unknown) : X,Y.
  - Doppler values at this time: D lat D long
- let time T_2 be first satellite fix after official start.
  - Satellite location at this time: S_2 lat S_2 long
  - Doppler values at this time: D_2 lat D_2 long

Location of the ship at time T is given by

$$X = S_1\,\text{lat} + \frac{(S2\,\text{lat} - S_1\,\text{lat}) \times (D\,\text{lat} - D_1\,\text{lat})}{D\,\text{lat} - D_1\,\text{lat}}$$

$$Y = S_1\,\text{long} + \frac{(S_2\,\text{long} - S_1\,\text{long}) \times (D\,\text{long} - D_1\,\text{long})}{D_2\,\text{long} - D_1\,\text{long}}$$

(Similar computation is made for official stop)

APPENDIX No. 6

SMOOTHING OF A CURVE BY "SMOUZE" PROGRAMME.

The purpose of this appendix is to explain the smoothing used in the automatic drawing of the offset frequency curve to get the predicted frequency necessary to the post - calculation of satellite fix data. The programme of automatic drawing is called SPOOF, designed around SMOUZE, a CGG Subroutine for smoothing of a curve which is described now.

The main points of SMOUZE are as follows:

* The curve output must remain third degree polynomial, within intervals larger than or equal to 2 points. As the adjustment conditions remain the same as those used in the CGG subroutine SPLINE (See § navigation), the curve will not be able to fit exactly through the points.

* The sum of the squares of the third derivatives, must be as small as possible.

In a more accurate way, SMOUZE processing corresponds to the following hypothesis and conditions

1. <u>Given</u>:

   a. N points x_i, Y_i each one weighted by P_i

   b. K "nodes", of which only abscissas X_k are given with $K \leq N$

c. ξ_i such that $\xi_1 \geq X_1$ and $\xi_1 \leq X_k$ (abscissas)

d. stabilization constants

2. Conditions

a. Between successive nodes, the curve is a third degree polynomial called S(x).

b. At each node, continuity of first and second derivative is assumed, the two curves having the same ordinate.

c. The sum of the squares of the differences in ordinates between the curve and the given points, weighted by the weights of these points and increased by stabilization constants is minimum.

d. The stabilization constants are proportional to:

* On the one hand; the sum of the squares of the third derivatives at the nodes, a larger weight being given to the first and last nodes.

* On the other hand, the sum of the squares of the ordinates at the nodes.

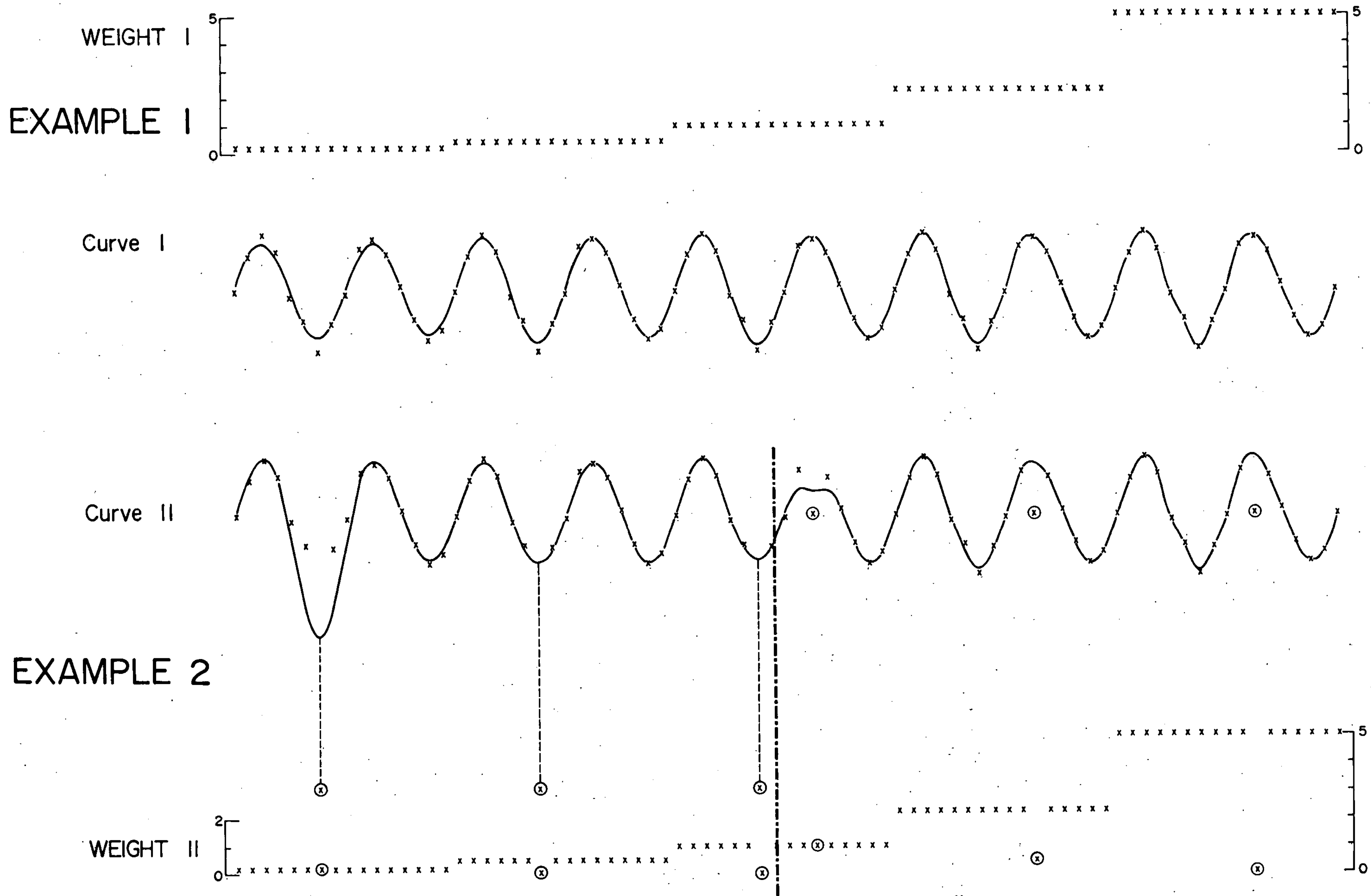
3. Output:

The ordinates η_n of the curve drawn, corresponding to the abscissas ξ_n are output.

Mathematical formulation of the conditions.

Conditions b and c, yield to minimise, taking in account the constraints of conditions a and b, the expression.

$$R^2 = \sum_i P_i^2 \, (Y_i - S_i) + \nu^2 \sum_k S_k'''^2 + \mu^2 (S_1'''^2 + S_k'''^2) + \beta^2 \sum_k S_k{}^2$$



SMOOTHING OF CURVES BY "SMOUZE" METHOD

FIG. 67

where $S_i \equiv S\ (x_i)$

$S_k \equiv S\ (X_k)$

The constraints are input in the following way =

1. The polynomial S(x) between two nodes is an expression of the second derivatives M and of the ordinates F of the curve at the two nodes.

$$S(x) = \frac{M_{k-1}(X_k - x)^3 + M_k(x - X_{k-1})^3 + (6F_k - M_k l_k^{\,2})(x - X_{k-1}) + (6F_{k-1} - M_{k-1} l_k^2)(X_k - x)}{6\ l_k}$$

where $l_k = X_k - X_{k-1}$

The unknowns of the problem will be the K values of M and the K values of F; as thére is only one value of M and one value of F at each node, the continuity of second derivatives and ordinates will be automatically worked out.

2. The continuity of the first derivative is assumed by the solution of the K-2 equations:

$$L_k \equiv \frac{l_k M_{k-1} + 2(l_k + l_{k+1}) M_k + l_{kM} M_{k+1}}{6} - \frac{l_{k+1} F_{k-1} - (l_k + l_{k+1}) F_k + l_k F_{k-1}}{l_k\ l_{k+1}} = 0$$

where $2 \leq k \leq K$

This problem of linked minimum is solved by using the Lagrange multipliers and by making minimum the expression

$$R^2 - 2 \sum \lambda_k \cdot\ L_k$$

which yields a system of 3K - 2 linear equations at 3K - 2 unknowns:

K values of M

K values of F

K-2 values of λ_k.

Gathering together in a convenient way equations and unknowns, the matrix of the system will have only non-zero values on the main diagonal and on 5 diagonals on both sides, allowing a solution even for a large number of nodes.

The stabilization values have been defined, for a try, in this way:

: β, Stabilizer of F is a quantity without dimension equal to 10^{-5}

: ν, Stabilizer of M has the dimensions $(\text{metre})^2$. It is defined by

$$\nu = \left\{ \left(\frac{X_k - X_1}{K-1} \right)^2 . \ 0.05 + \frac{\sum_k DM_k}{K} \right\} \varepsilon$$

- where DM_k is the diagonal term of the matrix relative to variable M_k
- while ε is a given value: (0.01)

  the larger ε is given, the smoother, the curve will be.
- and μ stabilizes the 2 ends of the curve and is equal to 5ν.

EXAMPLES

1. Curve I (fig. 67): At the start, the curve was a sine function lightly distorted. The weights have been given as

increasing from the left to the right. It is noteworthy that the curve, after processing is smooth when the weights are small, and it follows closer the given points as the weights are larger.

2. <u>Curve II (fig. 67)</u> The curve II is the same as curve 1 except for 6 points. In the first half of the curve, 3 points have been put strongly below the curve: the first one, which has the same weight as its neighbouring points, heavily distorted the processed curve, while the last one which has an approximately zero weight does not distort the curve. The same remark can be made for the second half of the curve, wherein 3 points located initially on the maxima of the curve have been relocated on the axis.

<u>Remark</u>:

SMOUZE can be used as a non linear filtering to filter phenomena of period P smaller than a given P_0 on a curve, without distorting too much phenomena of period greater then P_0 . SMOUZE can be used in the following way: After separation of high and low frequency using median filtering of period P_0, a low of weighting giving a low weight to all portions of the high frequency component curve that have a period smaller than P_0 is determined. SMOUZE, then, outputs the smoothed curve.